Nevada Statewide Greenhouse Gas Emissions Inventory and Projections, 1990-2030

Nevada Division of Environmental Protection

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Disclaimers

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Acronyms and Abbreviations

AVMT	Annual Vehicle Miles of Travel
AZNM	Arizona-New Mexico sub-region of NERCC grid
BOD	Biochemical Oxygen Demand
BTU	British Thermal Units (It measures energy content per unit of mass)
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide equivalents
CH_4	Methane
DETR	Nevada Department of Employment Training and Rehabilitation
eGRID	U.S. EPA Emissions & Generation Resource Integrated Database
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
FIA	USDA-Forest Service Inventory and Analysis Program
GDP	Gross Domestic Product
GHG	Green House Gas
GWP	Global Warming Potential
HDDV	Heavy duty diesel vehicle
HDGV	Heavy duty gasoline vehicle
HFCs	Hydrofluorocarbons
IP	Industrial Processes
IPAA	Independent Petroleum Association of America
IPCC	Intergovernmental Panel on Climate Change
IRP	Integrated Resource Plan
kWh	kilowatt-hours
LDDT	Light duty diesel truck
LDDV	Light duty diesel vehicle
LDGV	Light duty gasoline vehicle
LDGT	Light duty gasoline truck
LF	Landfill
LFG	Landfill Gas Collection System
LFGTE	Land Landfill-Gas-to-Energy System
LMOP	Landfill Methane Outreach Program
MC	Motorcycles
Mt	Metric ton (equivalent to 1.102 short tons)
MMt	Million Metric tons
$MMtCO_2e$	Million Metric tons Carbon Dioxide equivalent
MSW	Municipal Solid Waste
NDEP	Nevada Division of Environmental Protection
NEMS	National Energy Modeling System
NERC	North America Electric Reliability Corporation
NIFC	U.S. National Interagency Fire Center
NPC	Nevada Power Company
NPIRP12	2012 Integrated Resource Plan for Nevada Power Company
N_2O	Nitrous oxide
NWPP	North-West sub-region of NERCC grid
ODS and ODSs	Ozone Depleting Substance(s)
ODSS	Ozone Depleting Substance Substitute
PFCs	Perfluorocarbons
PHMSA	U.S. Department of Transportation Pipeline and Hazardous Material Safety Administration
RCI	Residential, Commercial, and Industrial
SEDS	U.S. EIA State Energy Data System
SF_6	Sulfur hexafluoride

SIT	U.S. EPA State GHG Inventory Tool
SPPC	Sierra Pacific Power Company
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Service
VMT	Vehicle Miles of Travel
WECC	Western Electricity Coordinating Council
WIP	Waste In Place
WRAP	Western Regional Air Partnership

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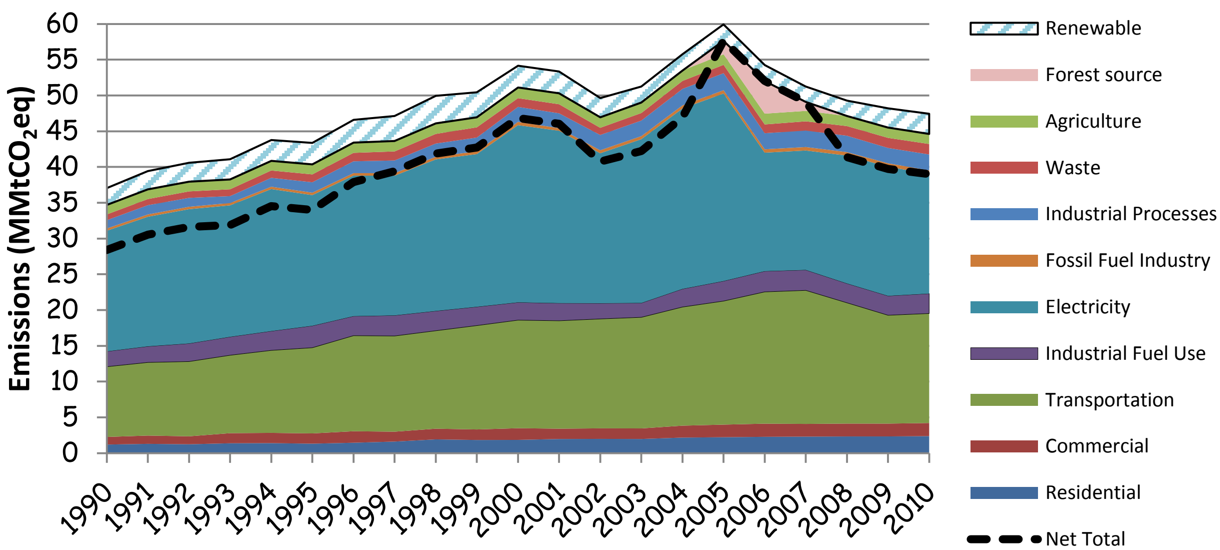
Executive Summary

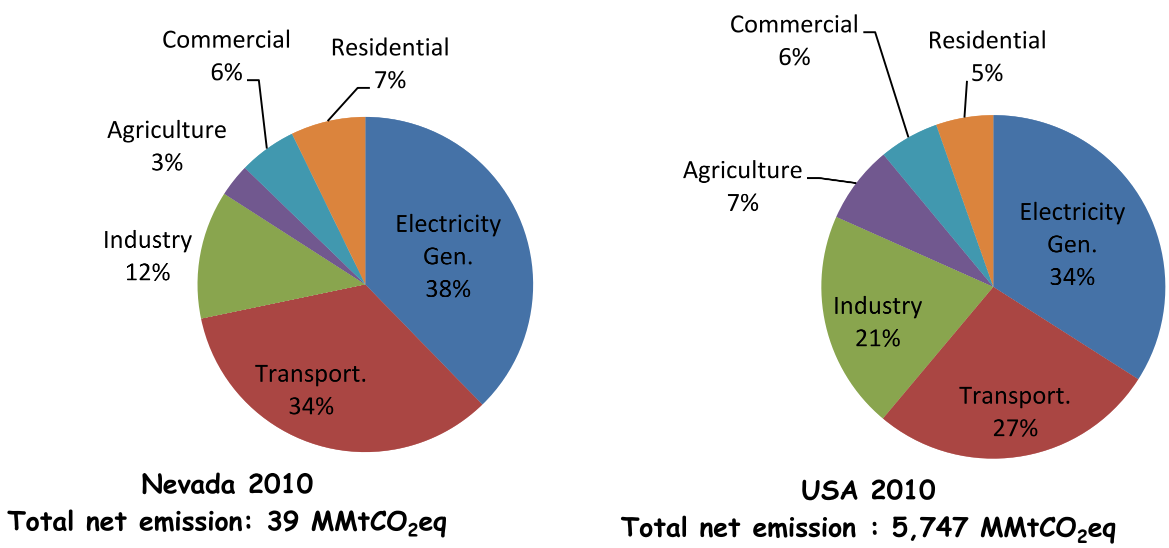
The analysis of Nevada's GHG emissions indicates that for 2010 (the most recent year with datasets available for all the considered GHG sources) statewide gross GHG emissions (i.e., without accounting for the carbon sequestered by the forest sector) totaled 45 million metric tons of carbon-dioxide equivalents (MMtCO_2eq) and net GHG emissions (i.e., including the forest sink) totaled 39 MMtCO_2eq (Figure ES1 and Table ES1). For the same year, total gross and net emission for U.S. totaled 6,822 and 5,747 MMtCO_2eq, respectively. Therefore, both net and gross GHG emissions in Nevada accounted for 0.7% of total national emissions.

Figure ES1: Total statewide annual emissions (MMtCO_2eq) from 1990 to 2010. Total gross emissions are disaggregated by economic sectors. The black dashed line is the net total annual emissions (gross total minus forest absorption). Emissions from the forestry sector are shown only during those years when this sector positively contributed to an increase of statewide GHG emissions. The 'Renewable' portion of the graph represents the hypothetical GHG emissions that renewable power generation in Nevada would cause if converted into fossil fuel-based generation.



GHG emissions were dominated by CO_2 (83% on average for the entire 1990-2010 period, 87% in 2010), followed by CH_4 (11% on average, 8% in 2010), N_2O (4% on average, 2% in 2010) and HFCs, PFCs and SF_6 (2% on average, 3% in 2010). Electrical power generation and transportation sectors were responsible for the large majority of GHG emissions in Nevada, with 38% and 34% of the total emissions, respectively in 2010 (Figure ES1 and Table ES1). The commercial and residential sector contributed with 10%, and industrial sector with 12%. Agriculture and waste management accounted for the residual 6% (Figure ES1 and Table ES1). Nevada forests sequestered about 13% of the total gross emissions in 2010. The significant contribution of the electricity generation and transportation sectors to total GHG emissions is confirmed at national level, with these two sectors contributing 61% of total U.S. GHG emissions. However, there are significant differences between Nevada and U.S. in the relative contribution of each economic sector (Figure ES2). In particular, the transportation contribution was larger in Nevada than in U.S. (34% vs. 27%); the industrial sector (power generation, non-energy related processes, and fossil-fuel industry) contributed 12% of total emission in Nevada and 21% in U.S; the agriculture sector contributed 3% of total emissions in Nevada and 7% in U.S.

Figure ES2: Relative contribution of each economic sector to total GHG emissions in Nevada and in the USA for the year 2010. In this graph, the industrial sector includes GHG emission from industrial fossil fuel burning, industrial processes, and fossil fuel industry. Emissions from waste management are included in each of the economic sector. Individually, the waste management sector contributed to 1.9% of total national emissions and 3% of Nevada emissions, in 2010.



From an historical perspective, gross GHG emissions rose with a pace of about 1.5 MMtCO2 per year from 1990 to 2005, but this trend reverted in 2006 and emissions started declining with a pace of about -1.8 MMtCO$_2$ per year (Figure ES1 and Table ES1). This change was mainly caused by the decommissioning of the coal-based Mohave Generating Station in 2006 and by the economic downturn that caused reduction in economic growth and hence emissions from all the economic sectors between 2007 and 2010. Historical data also underlines a substantial reduction in the relative contribution of the electricity generation in Nevada, which went from 49% in 1990 to 38% in 2010, despite a constant increase in electricity consumption between 1990 and 2007. The decommissioning of the coal-based Mohave Generating Station and a decline in emission factors, likely linked to a gradual change in fossil fuel used for power generation (e.g. from coal to natural gas) were the main causes for this shift. As total emissions in the electricity sector decreased, the contribution of the transportation sector to Nevada emissions increased from 28% in 1990 to 34% in 2010. The contribution of all other economic sectors did not substantially changed over the period of this report, with the exception of the Residential and Commercial sectors, which combined went from 7% in 1990 to 10% in 2010.

GHG emissions in Nevada are expected to regain a positive trend in the years following 2010 and increase during the projection period (2011-2030) with an average pace of about 0.3 MMtCO$_2$ per year (Figure ES3). This trend will be mainly supported by a moderate population and economic growth. Total gross emissions are expected to reach 53 MMtCO$_2$ by the year 2030 (Table ES1). However, emissions in the electricity generation sector are expected to maintain a negative, albeit very small, trend, caused by the relative low-to-moderate economic and population growths and increased use of 'cleaner' energy (e.g., natural gas and renewables). As a result, the transportation sector is expected to become the largest contributor of GHG emissions in Nevada in the early part of the projection period and reach 39% of total gross emissions by 2030 (versus 32% of the electricity generation sector, Table ES1)

Figure ES3: Total statewide projected annual emissions from 2011 to 2030. Total emissions are disaggregated by economic sectors. The black dashed line is the net total annual emissions (gross total minus forest absorption). Emissions from the forestry sector are shown only during those years when this sector positively contributed to an increase of statewide GHG emissions. The white vertical bar marks the end of historical data and the beginning of projections.

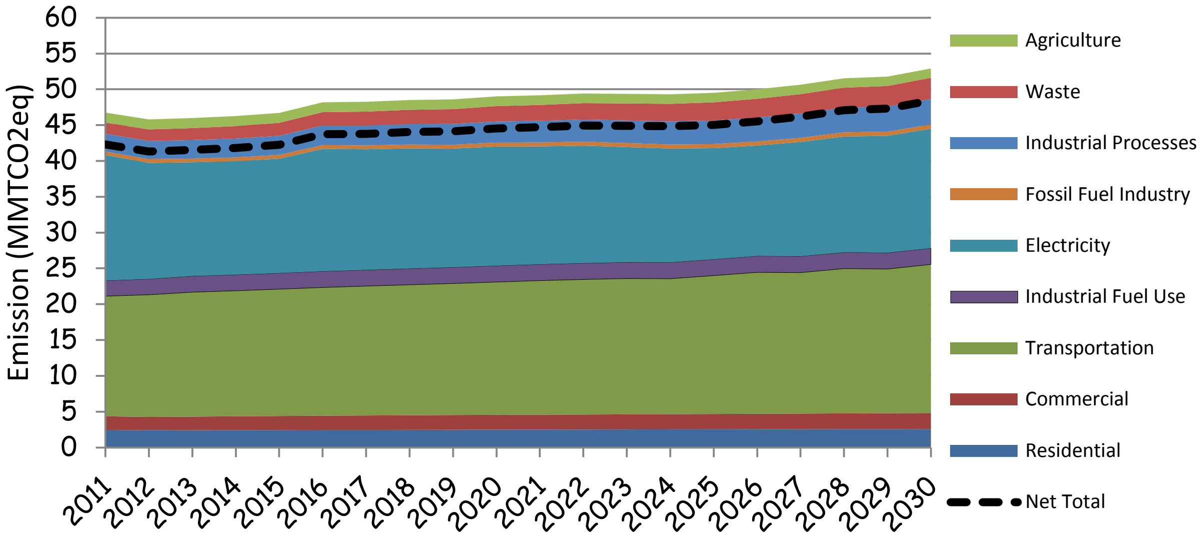


Table ES1: Nevada Historical and Projected Emissions by Sector. The industrial sector includes emissions from power generation, industrial processes, and the fossil fuel industry. Forest sink was positive in 2005 due to very large wild fires which offset carbon sequestration. All emissions are in MMtCO$_2$eq and totals may not equal exact sum of subtotals due to independent rounding.

Sector	1990	1995	2000	2005	2010	2015	2020	2025	2030
Power Generation	16.9	18.3	24.8	26.2	16.7	16.0	16.6	15.5	16.7
Coal	15.3	14.9	18.1	18.1	7.1	8.1	8.0	8.1	8.1
Natural Gas	1.3	3.4	6.6	8.1	9.6	7.8	8.6	7.4	8.5
Oil	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Transportation	9.8	12.0	15.1	17.3	15.3	17.7	18.5	19.3	20.7
Industrial	3.6	4.9	5.0	5.6	5.5	5.4	5.8	6.1	6.4
Residential and Commercial	2.3	2.8	3.5	4.0	4.2	4.4	4.6	4.7	4.8
Agriculture	1.3	1.4	1.5	1.5	1.4	1.4	1.4	1.3	1.3
Waste	0.8	1.1	1.2	1.2	1.5	1.8	2.1	2.5	3.0
Total Gross Emissions	**34.7**	**40.4**	**51.1**	**57.7**	**44.6**	**46.7**	**49.0**	**49.5**	**52.9**
Forest Sink	-6.3	-6.4	-4.3	1.9	-5.6	-4.5	-4.5	-4.5	-4.5
Total Net Emissions	**28.4**	**34.0**	**46.8**	**57.7**	**39.0**	**42.2**	**44.6**	**45.0**	**48.4**

1 Introduction

1.1 Overview

During the 2007 Nevada Legislative Session, the legislature passed Senate Bill 422, which is now codified in Nevada Revised Statutes Chapter 445B.137 and 445B.380. NRS 445B.380 requires that a statewide greenhouse gas (GHG) inventory be prepared and issued, at least every four years beginning in 2008. It further stipulates that the report must include the origin, types and amounts of greenhouse gases emitted throughout the State, and all supporting analyses and documentation. The first report of this series was released in 2008 and included the analysis of Nevada's GHG emissions from 1990 to 2005[1]. Like the previous report, this current, second, report presents a comprehensive inventory of all GHG emissions associated with human activities in Nevada. It includes all six GHGs covered by the US and other national and international inventories: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). These gases have characteristic global warming potentials (GWP) and therefore contribute differently to the overall atmospheric greenhouse effect. GWP is used to derive a common metric, CO_2- equivalent (CO_2eq), which uses the GWP of CO_2 as a reference unit. The use of CO_2eq allows estimating and comparing total GHG emissions from sources emitting different GHG gases. The 2012 report covers the period from 1990 to 2010 (historical and current emissions), and projects future emissions to 2030. It is important to notice that historical emissions reported in the 2012 inventory may slightly differ from those reported in the 2008 inventory. This may be because of improved methodologies, revised datasets, and differences in recommendations and assumptions adopted in the two reports.

The 2012 report is organized into chapters covering each of the economic sectors that produce GHGs:

- Electrical Generation from fossil-fuel burning
- Residential, Commercial, and Industrial (RCI) - Stationary emissions from fossil-fuel burning only
- Fossil-fuel industry (e.g., coal and natural gas production and distribution)
- Industrial Processes (i.e., all non-energy related activities)
- Transportation – Mobile emissions from fossil fuel burning
- Agriculture – All non-energy related activities
- Waste management
- Land Use, Land-use change, Forestry

The presence (or absence) of specific activities in each sector largely determine the type of GHG emitted. For instance, because no significant amount of solid waste is combusted in Nevada's landfills, neither CO_2 nor N_2O are released by the waste management sector. Table 1.1 summarizes the type of GHG emissions that each economic sector in Nevada is expected to release.

[1] Nevada Statewide Greenhouse Gas Emissions Inventory and Projections, 1990-2020

Table 1.1: Type of GHG emissions released by each economic sector in Nevada. A green box indicates that the specific GHG is released by the economic sector.

Sector	CO_2	CH_4	N_2O	HFCs	PFCs	SF6
Electrical Generation	■	■	■			
Residential, Commercial, Industrial (fossil fuel burning for energy-related activities)	■	■	■			
Fossil fuel Industry		■				
Industrial Processes (non-energy related activities)	■		■	■	■ **	■
Transportation	■	■	■			
Agriculture		■	■			
Waste Management		■	■			
Land Use, Land-Use Change, and Forestry	■ *	■	■			

** CO_2 can be emitted into the atmosphere and sequestered from the atmosphere in this sector*
*** HFCs, PFCs, and SF6 are grouped together in this sector*

1.2 Approach, Datasets, and General Methodology

The principal goal of this report is to provide a general understanding of Nevada's historical, current, and projected GHG emissions. In most cases, the approach followed was the same as the one used by the US-EPA in its national GHG emission inventory and those suggested in its guidelines for states[2]. These inventory guidelines were based on the recommendations developed by the Intergovernmental Panel on Climate Change[3], an international organization responsible for, among other tasks, coordinating methods for national GHG inventories. US EPA State Inventory Tools (SIT 2012)[4] were used as a starting point for all inventories and projections. Initial estimates were then revised as more accurate state and local datasets became available. The key sources for the data used in this report are shown in Table 1.2. In gathering the data, and in cases where data sources conflicted, the highest priority was placed on local and state data and analyses, followed by regional and national data. In the absence of available data, the most appropriate statistical methodology was used to either interpolate or extrapolate the missing data points. The data and methodologies used in this report are specifically designed to compile GHG emission inventory at the state level and on annual time scale. For this reason, the scale of this emission inventory is too coarse to effectively measure and evaluate the results of individual GHG reduction programs or statute changes.

For the purpose of this inventory, emissions that were caused by activities that occurred within the geographical boundaries of the State of Nevada were reported. However, it is important to recognize that GHG emissions are not always spatially associated with the related activities. For instance, production (the source of emissions) and consumption of electrical power (the related activity) can take place at very different locations, sometimes in different states. This distinction is particularly critical in evaluating the impact of potential demand mitigation strategies. For example, reuse, recycling, and source reduction can lead to emission reduction from lower energy requirements in the material

[2] http://www.epa.gov/statelocalclimate/state/activities/ghg-inventory.html
[3] http://www.ipcc.ch, 4^{th} assessment, 2007
[4] http://www.epa.gov/statelocalclimate/state/activities/ghg-inventory.html

production (such as paper, cardboard, aluminum, etc…), even though the emissions associated with material production may not occur within the State. Given the critical role of the electrical power generation sector in the total GHG emission of Nevada, this report made use of different strategies to assess GHG emissions from this sector (see Section 3).

Table 1.2: Key sources for data used in the Nevada's GHG emission inventory.

Sector	Source	Information Provided
All sectors	U.S. EPA State GHG Inventory Tool, 2012 version (SIT 2012)	Emission factors
Electrical Generation	U.S. Energy Information Administration (EIA) • State Energy Data System (SEDS) • Form 861	Fossil-fuel consumption at state level
		Electricity consumption by residential, commercial, and industrial sectors
		U.S. Electricity retail sale by end-user sector
		Electricity net generation and purchase at company level
		Projected regional consumption for the period 2010-2030
	2010 U.S. Census	U.S. Population from 1990 to 2010
	US-EPA Emissions & Generation Resource Integrated Database (eGRID)	Emission rates ($MtCO_2eq/kWh$) at company, state, eGRID sub-region, and NERC region aggregation level
	Nevada Power Company (NPC) - 2012 IRP	Estimated and projected CO_2 emissions
Transportation	Nevada Department of Transportation	Total Annual Vehicle Miles Traveled (VMT)
	SIT 2012	VMT per vehicle type (national average)
	SIT 2012 and U.S. EIA –SEDS	Annual consumption of fossil fuel for the transportation sector, disaggregated by type of fuel
Residential, commercial, and industrial	SIT 2012	Emission factors (metric tons/BTU), energy content (BTU), combustion efficiency (%), and fraction of non-energy use (%)
	EIA-SEDS	Fuel consumption
Industrial processes	USGS Minerals Yearbook 2012	Annual production and consumption, and projected consumption for different minerals
	Nevada Department of Employment	Projected growth rates for different industrial activities
	U.S. EPA GHG Inventory for 2010	Sector emissions for 2010
	U.S. Census and NV State Demographer	US and Nevada population statistics
	U.S. EIA	National and Nevada's electricity consumption
	2011 EPA Non-CO_2 GHG Report 2010-2030 (DRAFT)	Projected consumptions and emissions
Fossil fuel industry	Independent Petroleum Association of America (IPAA)	Oil and natural gas production
	U.S. EIA	Oil and natural gas production
	U.S. Department of Transportation Pipeline and Hazardous Material Safety Administration (PHMSA)	Natural gas transmission and distribution
	NV State Demographer	Growth rates for natural gas distribution
Agricultural	USDA National Agricultural Statistics Service (NASS)	Livestock population and crop statistics for Nevada
	Nevada State Demographer	Population growth for fertilizer use projections
Waste management	U.S. EPA Landfill Methane Outreach Program (LMOP)	Waste in place (WIP) Information on gas-recovery technologies (in-place and planned)
	State of Nevada Solid Waste Management Plan (2007)	Annual solid waste emplacement
	Nevada State Demographer	Population statistics (1960-2010)
		Population estimated growth (2011-2030)
Land Use, Land-Use Change, and Forestry	USDA-Forest Service Inventory and Analysis Program (FIA)	Forest productivity
	National Interagency Fire Center (NIFC)	Acreage affected by fires

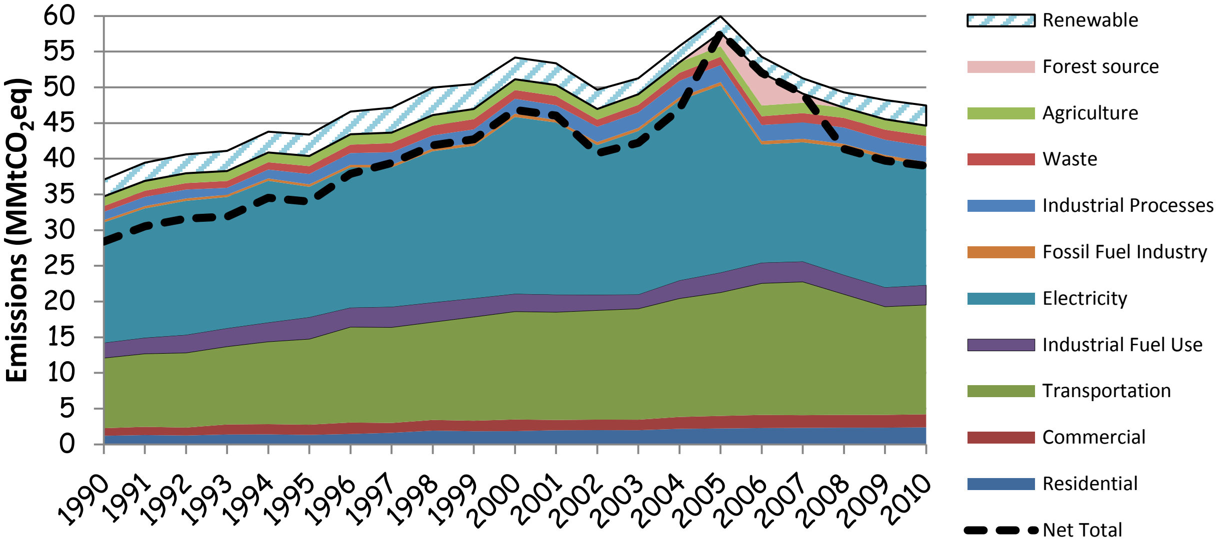
2 State of Nevada GHG Emissions

2.1 Historical and current emissions (1990-2010)

The analysis of Nevada's GHG emissions indicates that for 2010 (the most recent year with datasets available for most of the considered GHG sources) statewide gross GHG emissions totaled around 45 million metric tons of carbon-dioxide equivalents (MMtCO$_2$eq). The time-series for the total statewide emissions from 1990 to 2010 (historical data) is shown in Figure 2.1. In this figure, total emissions are disaggregated by economic sectors and the net emission from the forestry sector is shown only when positive (i.e., when this sector is overall emitting GHGs into the atmosphere). GHG emissions consistently increased in all sectors from 1990 to 2005, when total statewide gross GHG emissions peaked at approximately 58 MMTCO$_2$eq. GHG emissions from the electricity generation sector showed a sharp decline in 2006, when the Mohave Generating Station permanently closed. GHG emissions from all the sectors also showed a decline between the years 2007 and 2009 likely due to the economic downturn. Temperate forests in the Northern hemisphere are a sink of atmospheric CO_2 (i.e., they absorb more atmospheric CO_2 through photosynthesis than what they release through respiration/decomposition) and hence contribute to offset the total anthropogenic GHG emissions. This is the reason why the total annual **net** statewide emission is generally lower than the sum of each sector emissions (**gross** emission, see also Section 10). The exceptions are those years when fires (in particular wildfires) caused forests to be a net source of GHGs. Figure 2.1 also shows the hypothetical GHG emissions that renewable power generation would have caused if converted into fossil fuel-based generation (see Section 3 for details). In order to calculate these hypothetical emissions, the amount of energy produced by renewable technologies (geothermal, solar, and hydroelectric) was partitioned according to the contribution that each non-renewable technology (coal, natural gas, and petroleum) had for each year in the 1990-2010 period[5]. These hypothetical emissions are not used in any other analysis in the report and are shown here only for the historical dataset.

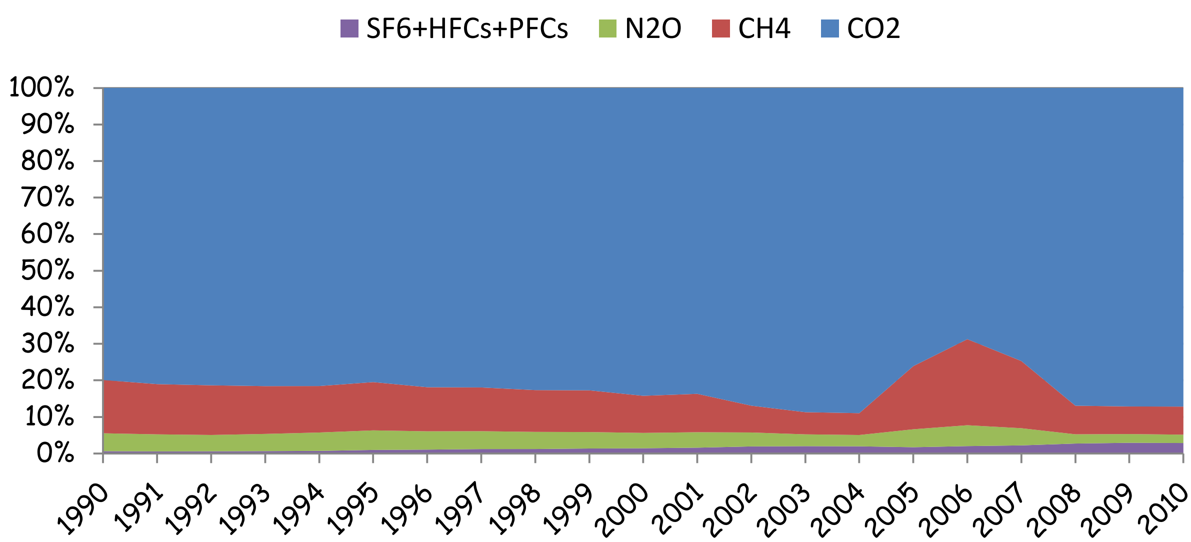
[5] US-EIA-SEDS

Figure 2.1: Total statewide annual emissions (MMtCO_2eq) from 1990 to 2010. Total gross emissions are disaggregated by economic sectors. The black dashed line is the net total annual emissions (gross total minus forest absorption). Emissions from the forestry sector are shown only during those years when this sector positively contributed to an increase of statewide GHG emissions. The 'Renewable' portion of the graph represents the hypothetical GHG emissions that renewable power generation in Nevada would cause if converted into fossil fuel-based generation.



Historically, GHG emissions were dominated by CO_2 (83% on average, 87% in 2010), followed by CH_4 (11% on average, 8% in 2010), N_2O (4% on average, 2% in 2010) and HFCs, PFCs and SF_6 (2% on average, 3% in 2010). The only exceptions are the years between 2005 and 2007, when large wildfires caused CH_4 emissions to contribute around 15-20% of the total GHG emissions (i.e., between 8 and 11 MMtCO_2eq were released by fires, see Section 11.5 for more details). Figure 2.2 summarizes the relative contribution of each GHG to historical total emissions in Nevada.

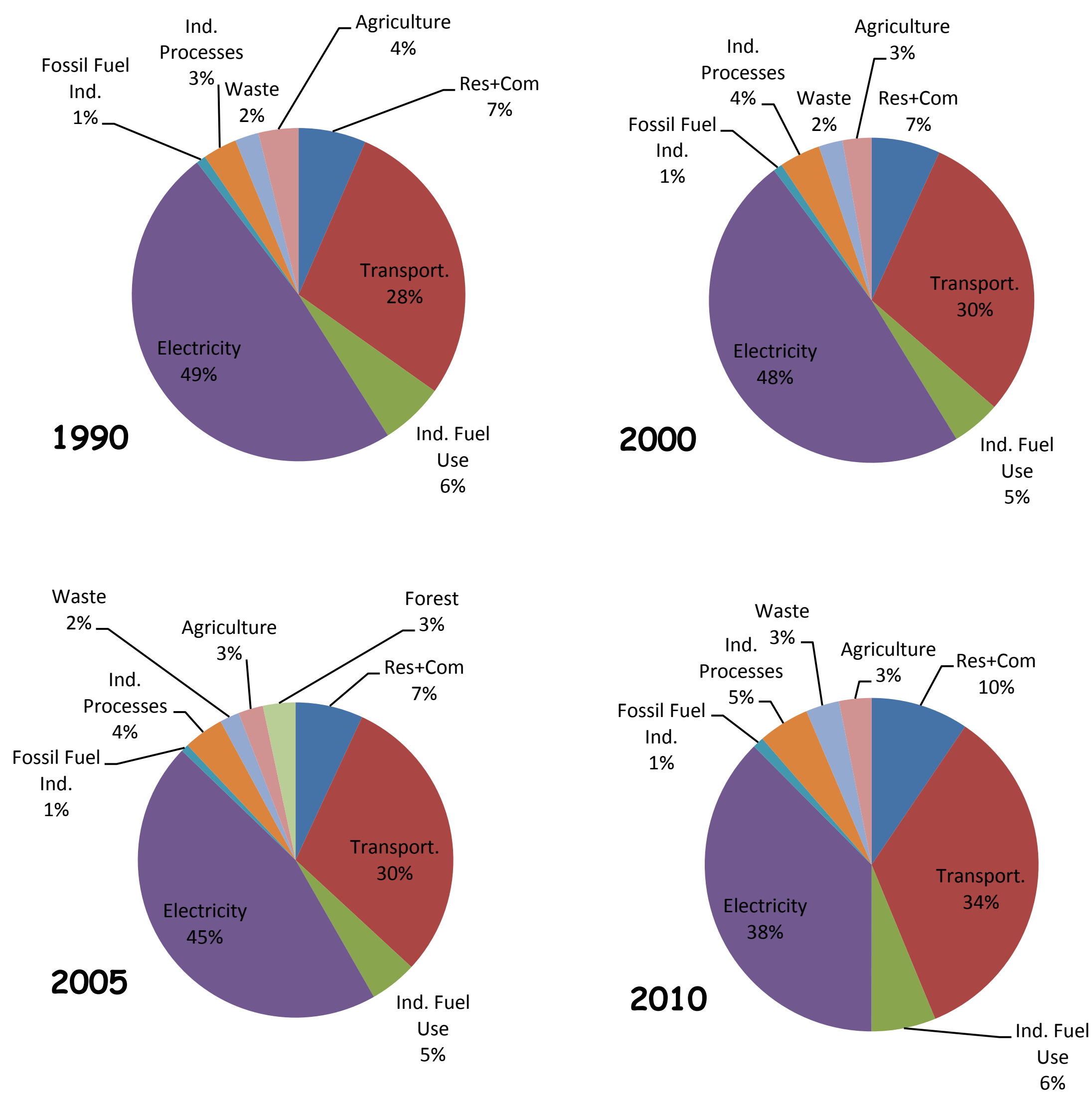
Figure 2.2: Relative contribution of each GHG to total emissions in Nevada



Electrical power generation and transportation sectors are responsible for the large majority of GHG emissions in Nevada, with 37% and 34% of the total emissions, respectively, in 2010. The commercial, residential, and industrial use of fossil fuels accounted for an additional 16% in 2010. On average, Nevada forests sequestered about 14% of the total emissions between 1990 and 2010. Once again, the years from 2005 to 2007 are exceptions as large fire disturbances contributed to offset the carbon sequestered by forests.

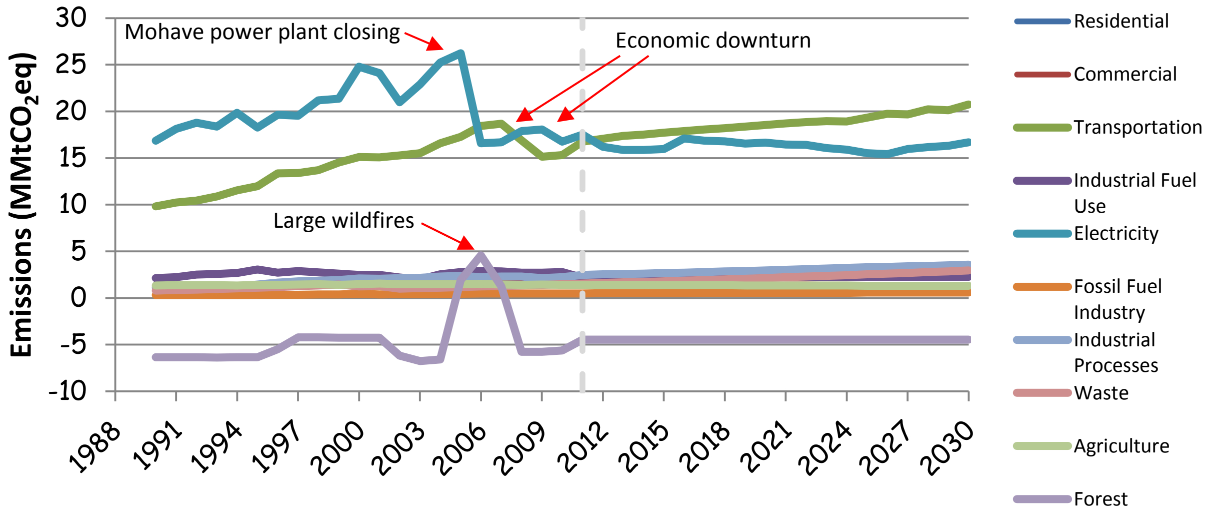
The relative contribution of each economic sector was constant for most of the period from 1990 to 2010 (Figure 2.3). The only difference is the relative contribution of the electrical power generation sector. In 2006 the Mohave Generating Station, the largest coal-fired power plant in the state, was closed without any equivalent replacement. This change resulted in a significant reduction in GHG emissions from this sector, with the consequent reduction in relative contribution to total state emissions from 45% in 2005 to 38% in 2010.

Figure 2.3: Relative contribution of each economic sector to Nevada's total GHG emissions.



A decrease in GHG emissions is visible in the time-series of most of the economic sectors between 2007 and 2009, as a result of the economic downturn (Figure 2.1 and Figure 2.4). Consumption and/or production drastically decreased in all economic sectors, though not always at the same time, causing associated GHG emissions to significantly decline as well. For the large majority of these sectors, emissions are again on the rise, potentially driven by an economic recovery. However, many sector emissions have not reached the same level of emissions that were observed before the beginning of the economic downturn.

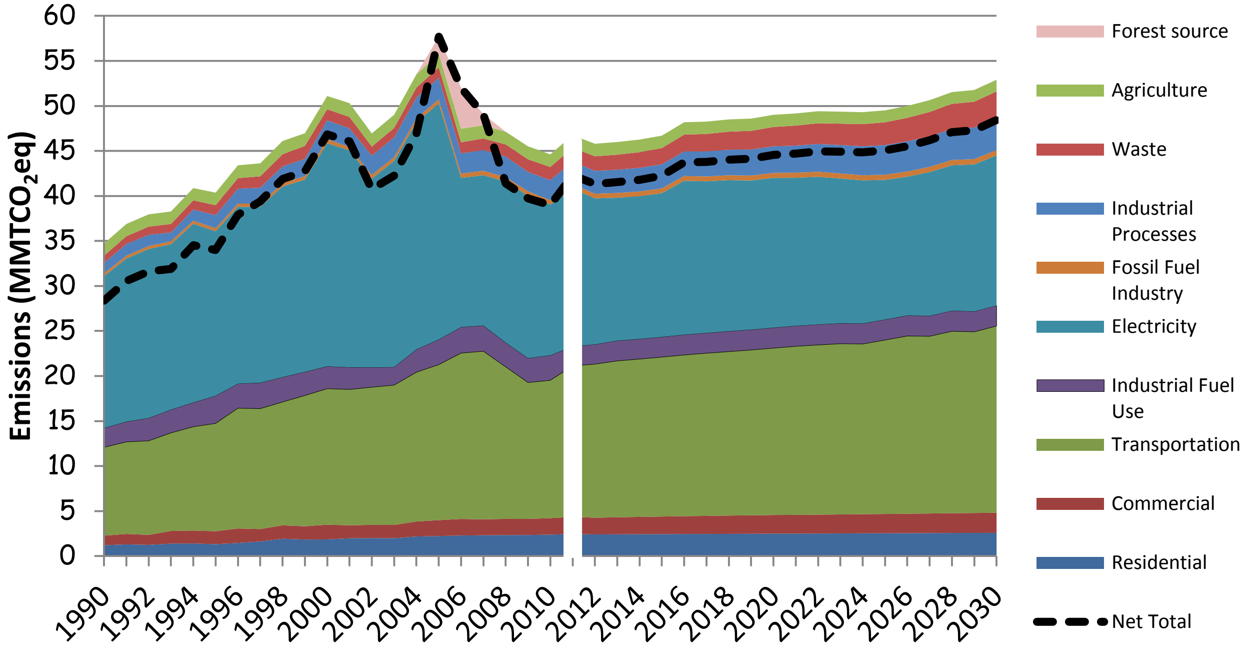
Figure 2.4: Statewide annual emissions (CO_2eq) for each economic sector from 1990 to 2010, and projections from 2011 to 2030. The gray vertical dashed line marks the end of historical emissions and the beginning of projections. The effects of the economic downturn are clearly visible in the transportation and electricity sectors between 2007 and 2009 (red arrows). The large decline in emissions from the electricity sector in 2006 resulted from the decommissioning of the Mohave power plant (red arrow). For most of the historical period, forests have contributed in offsetting GHG emissions (negative numbers). The exception is during 2006, when large wildfires caused this sector to be a net source of GHGs.



2.2 Projected Emissions (2011-2030)

Several assumptions were used to estimate GHG emissions for the period 2011-2030. These assumptions clearly affected the outcome for these years and are discussed in the chapters describing GHG emissions for each economic sector. There is a slow but constant increase in GHG emissions in all economic sectors for the period 2011-2030, mainly driven by predicted population and economic growth. Overall, these projections indicate that Nevada's net emissions of GHG will increase with a rate of about 340,000 MtCO$_2$eq per year, and reach about 50 MMtCO$_2$eq in the year 2030 (Figure 2.5). This is almost twice the emissions recorded in 1990, but still lower than the emissions reported for the year 2005 (around 60 MMtCO$_2$eq), before the decommissioning of the Mohave Generating Station and the beginning of the economic downturn. The main uncertainties in these projections are associated with the demand and production of electricity (and hence with the growth of population and economic production) and trends in the transportation sectors.

Figure 2.5: Total statewide annual emissions (MMtCO$_2$eq) from 1990 to 2010, and projections from 2011 to 2030. Total emissions are disaggregated by economic sectors. The black dashed line is the net total annual emissions (gross total minus forest absorption). Emissions from the forestry sector are shown only during those years when this sector positively contributed to an increase of statewide GHG emissions. The white vertical bar marks the end of historical data and the beginning of projections.

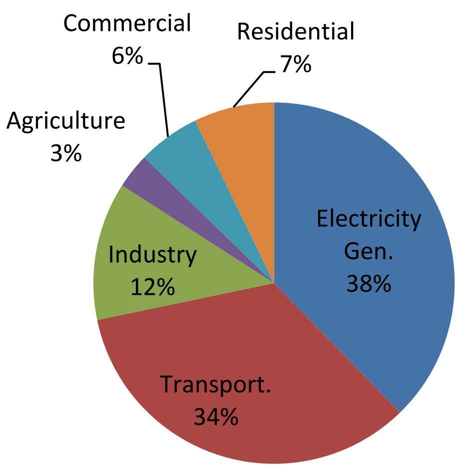


2.3 Nevada and the U.S.

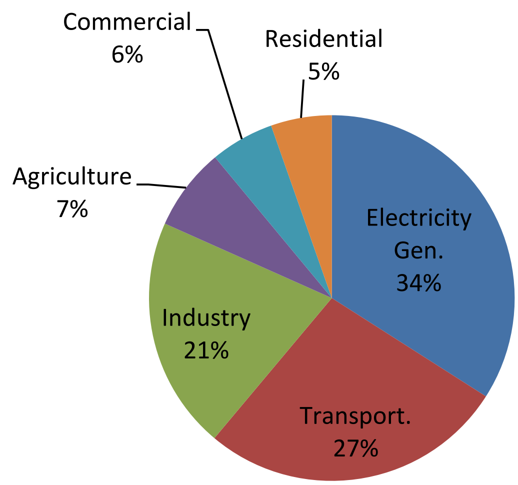
Total GHG emissions for the U.S. were 6,822 MMtCO$_2$eq in 2010[6]. Net emissions, after accounting for land use, land use change and forestry sinks, were estimated at 5,747 MMtCO$_2$eq. Therefore, Nevada accounted for about 0.7% of total US GHG net emissions. US GHG emissions are estimated to be 18.6 MtCO$_2$eq per capita, compared to 14.4 MtCO$_2$eq for Nevada (population data from 2010 U.S. Census[7]). The relative contribution of each economic sector in GHG emissions in Nevada slightly differed from the U.S. (Figure 2.6). Transportation emissions accounted for 34% of total emissions in Nevada, but only for 27% at the national level. Industrial sources (the total from fossil fuel combustion, industrial processes, and fossil fuel industry) accounted for 12% of total emissions in Nevada, but 21% for U.S.

[6] Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2010, April 15, 2012 – EPA 430-R-12-001
[7] http://2010.census.gov/2010census/

Figure 2.6: Relative contribution of each economic sector to total GHG emissions in Nevada and in the USA for the year 2010. In this graph, the industrial sector includes GHG emission from industrial fossil fuel burning, industrial processes, and fossil fuel industry.



Nevada 2010
Total net emission: 39 $MMtCO_2eq$



USA 2010
Total net emission : 5,747 $MMtCO_2eq$

3 Electrical Generation Sector Emissions

3.1 Overview

Energy-related activities (e.g., electricity generation and consumption, transportation, etc…) are the most significant contributors to U.S. GHG emissions, accounting for nearly 87% of total emissions in 2010[8]. Among these activities, electricity generation by fossil fuel burning is the top producer of GHGs, accounting for about 40% of total energy-related emissions. The amount of released GHGs (largely CO_2 and in smaller amounts, CH_4 and N_2O) depends on the type and quantity of fuel consumed during the production of electricity. Different types of fossil fuels contain (and therefore release) different amounts of carbon per unit of energy produced: coal contains the highest amount of carbon per unit of energy, followed by petroleum, and natural gas.

The US-EPA recommends two different approaches to estimate GHG emissions from the energy production sector, namely the **production-** and the **consumption-** based methods[4]. The production-based method uses the type and amount of fuel consumed by power plants to produce energy. Emission factors relating the amount of emitted CO_2, CH_4, and N_2O to fuel type and consumption are used to derive emissions expressed in CO_2eq. This approach accounts for all GHG emissions from burning fossil fuels used to produce electricity within Nevada, however, it does not consider the destination of the produced electricity (e.g., used within the state vs. exported out of state) as well as the GHG emissions from electricity imported from other states. The consumption-based method quantifies GHG emissions by taking into account electricity consumption for the industrial, commercial, and residential sectors in Nevada. This approach has the advantage of quantifying the actual electricity demand of the state and that it could be used to track the influence of factors such as electricity price changes and/or the effectiveness of consumer programs designed to reduce electricity consumption. However, assumptions on the emission rates (metric tons of GHGs per kWh) and transportation losses (from power-plants to end-users) add significant degrees of uncertainty to the estimates from the consumption-based approach. Also, the 'consumption-based' method does not distinguish between electricity generated and consumed within the state and electricity that is generated and imported from out-of-state producers. Indeed, this piece of information could be accessible through power companies, but it would still lack information about the type of energy sources used to produce exchanged electricity (renewable vs. fossil fuel, coal vs. natural gas, etc…). This uncertainty can introduce large errors in the estimates of GHG emissions associated with electricity production and exchange between-states. For these reasons, it is expected that the 'production-based' and 'consumption-based' approaches do not produce similar results. Nevertheless, comparing their results can reveal important dynamics in electricity production, consumption, exchange, and hence GHG emissions. In an effort to clarify these dynamics and reconcile the estimates from both approaches, an alternative method to quantify GHG emissions from electricity generation was developed (see section 3.2.3).

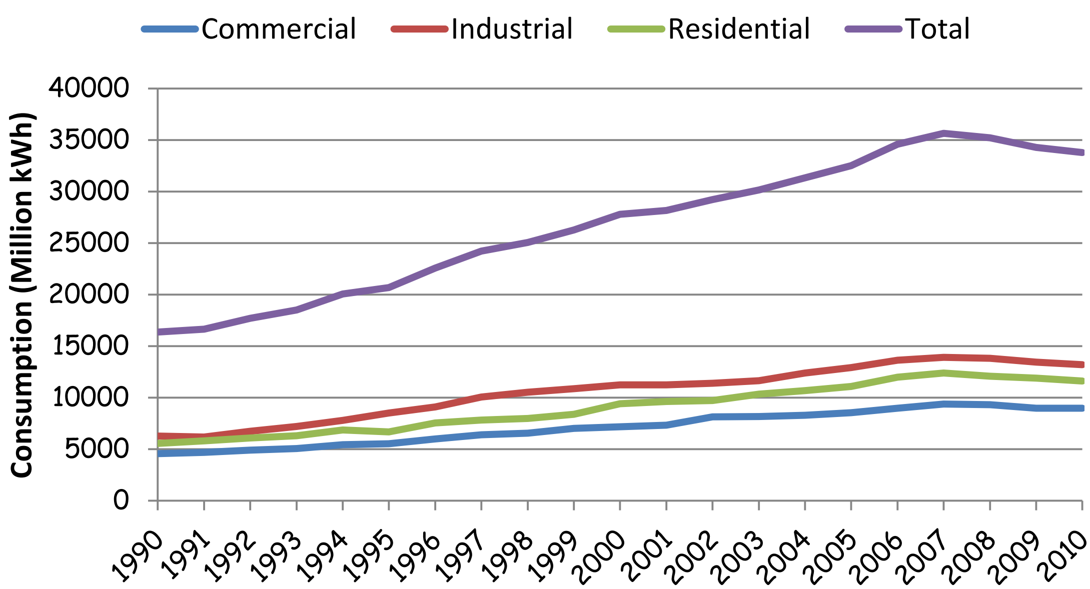
[8] Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2010, April 15, 2012 – EPA 430-R-12-001

3.2 Historical Production, Consumption and GHG Emissions

3.2.1 Historical Electricity Production and Consumption

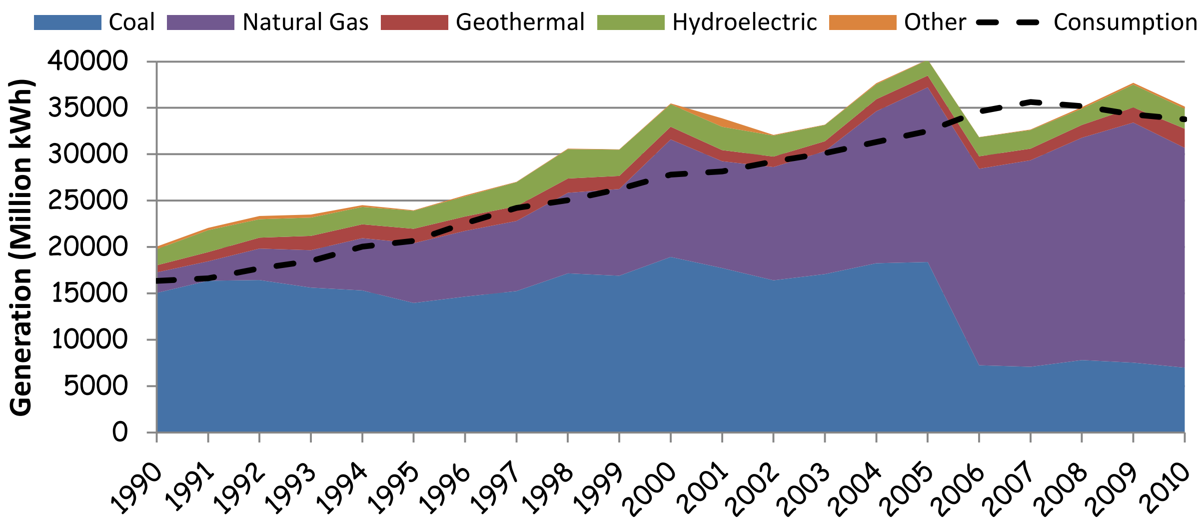
In terms of electricity consumption, all economic sectors showed a steady increase from 1990 to 2007 (Figure 3.1, data from U.S. EIA-SEDS). The industrial sector was the largest consumer of electricity (40% of the total), followed by residential (34%), and commercial (26%) sector. Starting from 2005, the transportation sector showed a marginal consumption of electricity (e.g., around 8 million kWh/year), but because of its very small contribution, this sector is not shown in Figure 3.1. Overall, electricity consumption more than doubled between 1990 and 2007, but like many other activities analyzed in this report, a sharp reduction was observed starting in 2007, as the economic downturn affected production and consumption in the U.S. and Nevada. This decline was similar in all the three sectors. In 2010, total electricity use in Nevada was 33,765 million kWh, that is, about 12,500 kWh/capita/year. In the same year, the pro-capita electricity consumption for the entire U.S. was 12,068 kWh/capita/year (data from U.S. EIA and 2010 U.S. Census).

Figure 3.1: Total electricity consumption (millions of kWh) for Nevada and disaggregated by economic sectors. The transportation sector is not shown in this graph as its contribution to total electricity consumption was negligible (approximately 8 million kWh starting from 2005). Source: U.S. EIA



The two major sources of electricity in Nevada have been coal and natural gas (Figure 3.2). A steady increase in the use of natural gas as fuel in power generation and the decommissioning of the Mohave Generating Station in 2006, have reversed the relative contribution of these two sources. In 1990, coal was used in 76% of non-renewable production of electricity; in 2010, natural gas accounted for 77% of the electricity production. Renewable energy production (geothermal, solar, and hydroelectric) contributed on average to 12% of the total production, with little variability across the years. This share is not directly comparable with the requirements on renewable portfolio that Nevada Legislature enacted in 1997. This is because: a) the renewable share presented in this section is not exclusively produced for Nevada consumption; b) a significant portion of the renewable portfolio used in Nevada is acquired through short-term purchases from other states ("Annual Report of Nevada Power Company d/b/a NV Energy and Sierra Pacific Power Company d/b/a NV Energy on compliance with the Portfolio Standard for Renewable Energy for Compliance Year 2011"[9]). Electricity consumption (as shown in both Figure 3.1 and Figure 3.2) was always lower than total electricity production, except in 2006 and 2008. However, this cannot be interpreted as an indication of Nevada's self-reliance on electricity production. As mentioned in Section 1.2, import and export of energy from and to other states is a very common practice, and production and consumption of electricity can be largely decoupled when the analysis is limited to a single state. An attempt to reconcile production- and consumption-based data was conducted for this report and is presented in section *3.2.3*.

Figure 3.2: Electricity generation (by source) and consumption in Nevada. The 'other' group includes petroleum, solar, and non-natural gas. Source: U.S. EIA



3.2.2 Historical GHG Emissions

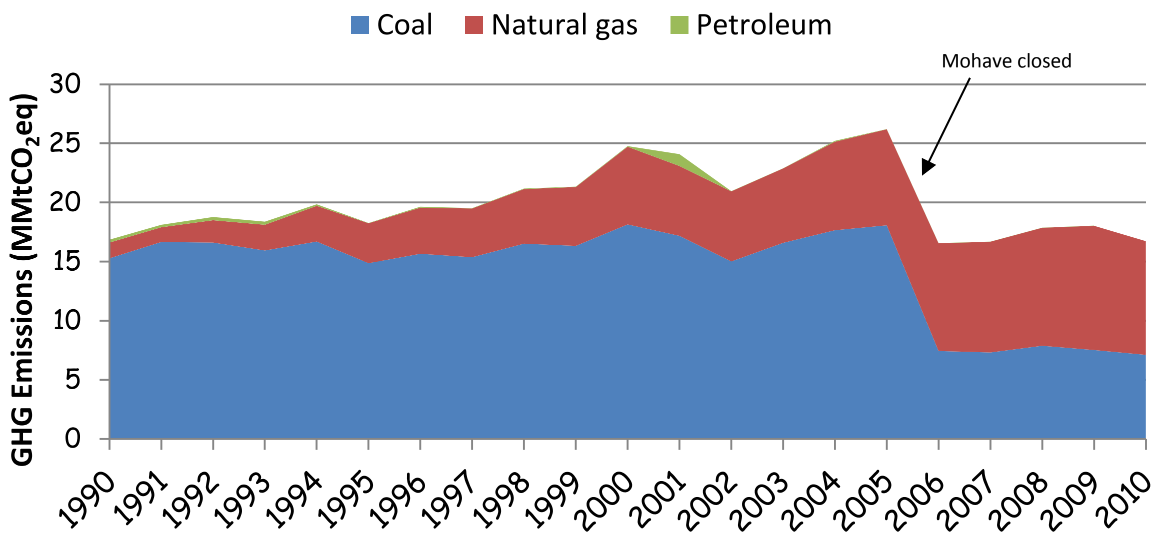
Historical emissions were calculated using fossil fuel consumption data ('production-based' approach) and 'end-user' electricity consumption data ('consumption-based' approach), available through the U.S. Energy Information Administration (EIA) for the period 1990-2010. GHG emissions from the electrical generation sector included mainly CO_2 (more than 99%), CH_4, and N_2O (less than 1% together). GHG emissions calculated with the production-based method are shown in

Figure 3.3 disaggregated by type of fossil fuel used. Coal burning largely dominated GHG production in the early 90's, when coal emissions accounted for about 90% of total emissions. From 1990 to 2005, total GHG emissions increased from about 17 to 25 MMtCO$_2$eq. Increased use of natural gas as a fossil fuel caused emissions from coal to decline and to contribute only 70% of total emissions in 2005. However, a sharp change in GHG emissions was caused by the closure of the Mohave Generating Station (coal-based) in 2006. This event not only caused a sharp decline in total GHG emissions (36% decline from 2005 to 2006), but also caused a reduction in relative contribution between coal and natural gas: in

[9] http://pucweb1.state.nv.us/PUCN/DktInfo.aspx?Util=Renewable – docket # 12-03036

2010, natural gas contributed to almost 60% of GHG emissions from electricity generation in Nevada. Historically, emissions from petroleum burning have been negligible in Nevada.

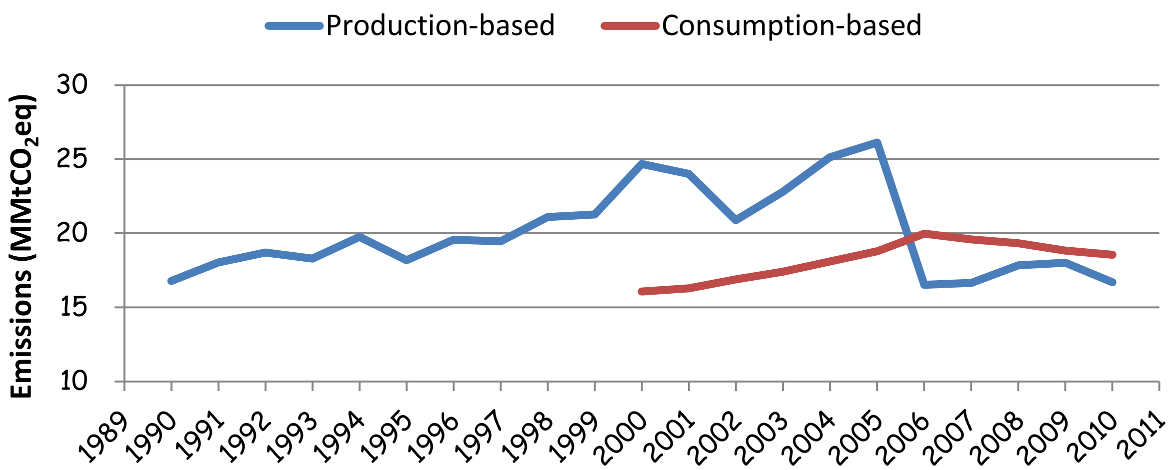
Figure 3.3: GHG emissions from electrical power generation, disaggregated by type of fossil fuel, and estimated using the production-based approach. Black arrow marks the year when the Mohave Generating Station was permanently closed.



GHG emissions calculated from electricity consumption are shown in Figure 3.4. Consumption-based emission and GHG rates first became available in 2000 whereas production-based emission and GHG rates have been available since 1990[10]. Emissions from the consumption- and production-based methods differed consistently from 2000 to 2005; emissions from the consumption-based method were about 70% of those calculated using the production-based method. Starting in 2006, the two methods produced similar results, with GHG emissions differing only by 13%, on average. The large difference in emissions between the consumption- and production- based approaches for the period 2000-2005 is in apparent disagreement with the small difference between the consumption and generation of electricity for the same period (Figure 3.2). This is likely the result of more complex dynamics between electricity production and consumption in Nevada, most importantly, the import and export of electricity across the state borders. In an effort to clarify these dynamics, a different approach to quantify GHG emissions from electricity generation was developed (see section 3.2.3).

[10] data from U.S. EPA-eGRID http://www.epa.gov/cleanenergy/energy-resources/egrid, and U.S. EPA-SIT 2012

Figure 3.4: Total GHG emission from electricity production (consumption-based method) and fossil-fuel burning (production-based method)



3.2.3 Alternative approach to quantifying GHG emissions from the electric generation sector

Nevada is part of the interconnected region managed by the Western Electricity Coordinating Council (WECC[11], Figure 11.2). Due to this interconnection, electricity generated in Nevada can be exported to serve needs in other states and, conversely, electricity used in Nevada can be generated and imported from plants outside the state. This network has degrees of spatial and temporal variability that span over decades (for instance with the construction or decommissioning of power plants) but more often just over seasons (as the network adjusts to compensate for higher or lower demand from different points of the grid). GHG emissions from electricity production largely depend on the type of fuel used in the generation processes (for example coal vs. natural gas burning, or renewable energy). Therefore, in order to accurately estimate Nevada's GHG emissions from power generation, it is critical to track the sources of electricity directly associated with those commercial, industrial, and residential activities that take place only within the state. Since almost all states are part of regional trading grids, many states that have developed GHG inventories have grappled with the problem of how to account for flows of electricity across the state borders. In particular, an inventory of all the origins and destinations of the electricity flowing from, to, and across Nevada would be not only extremely time-consuming, but inherently undermined by the lack of detailed data required for its completion. The approach presented here represents a compromise between the coarse GHG emission assessment provided by the production- and consumption-based methods, and a detailed analysis of all the electricity flowing across the state. Figure 3.5 describes the main electricity patterns and GHGs sources considered in our alternative approach. The main assumption is that the reported statewide electricity consumption (i.e., retail sales) equals the power generated by intrastate power companies to fulfill Nevada's activities plus the electricity purchased from out of state (and exclusively delivered within Nevada). If so, it is possible to estimate the GHG emissions produced by out of state power generation (assuming an average emission rate for the entire WECC region), the power generated and used within Nevada (the difference

[11] http://www.wecc.biz/Pages/Default.aspx

between end-user consumption and purchase of electricity), and therefore the emissions directly associated with intrastate generation (characterized by Nevada-specific emission rates).

[Consumption - Purchase]=Electricity produced and consumed within Nevada

Emissions = (Purchase x WECC Emission Rate) + ([Consumption - Purchase] x NV Emission Rate)

A detailed explanation of this method can be found in Appendix 11.1.

Figure 3.5: Diagram describing the main sources of GHGs emissions and electricity flows that support Nevada's consumption. This framework was used to develop the alternative method to estimate GHG emissions. Electricity production occurs either within or outside Nevada, and it is characterized by two different emission rates. The green arrows describe the electricity flows that are directly responsible for GHG emissions associated with Nevada activities. This is equivalent to the out-of-state electricity purchased by power companies operating in NV (and assumed to be re-sold within Nevada) plus the fraction of energy generated in NV that is directly sold to the residential, commercial, and industrial sectors in the state.

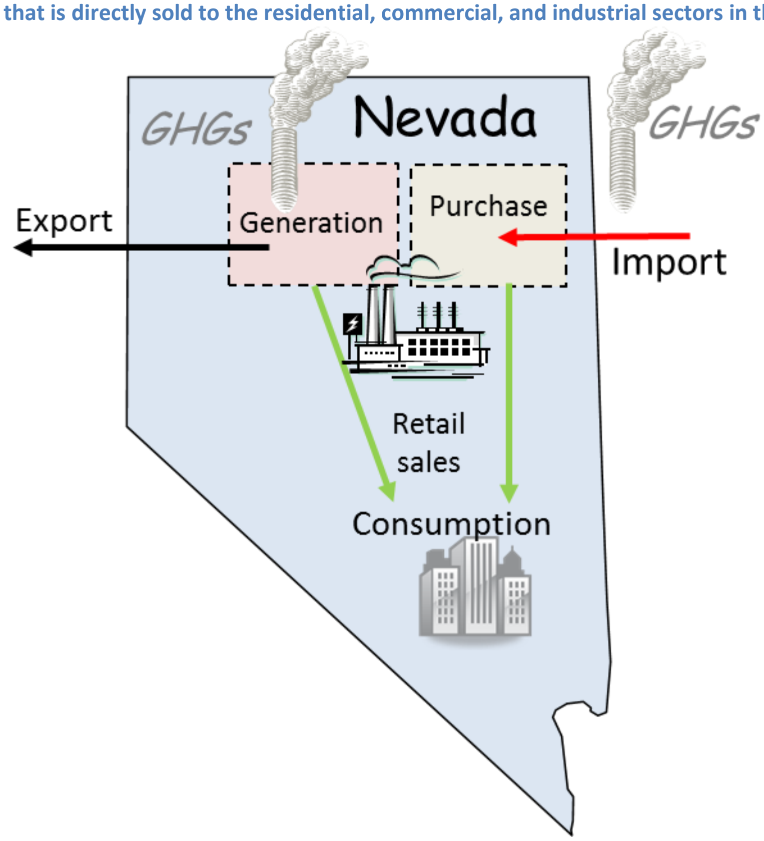
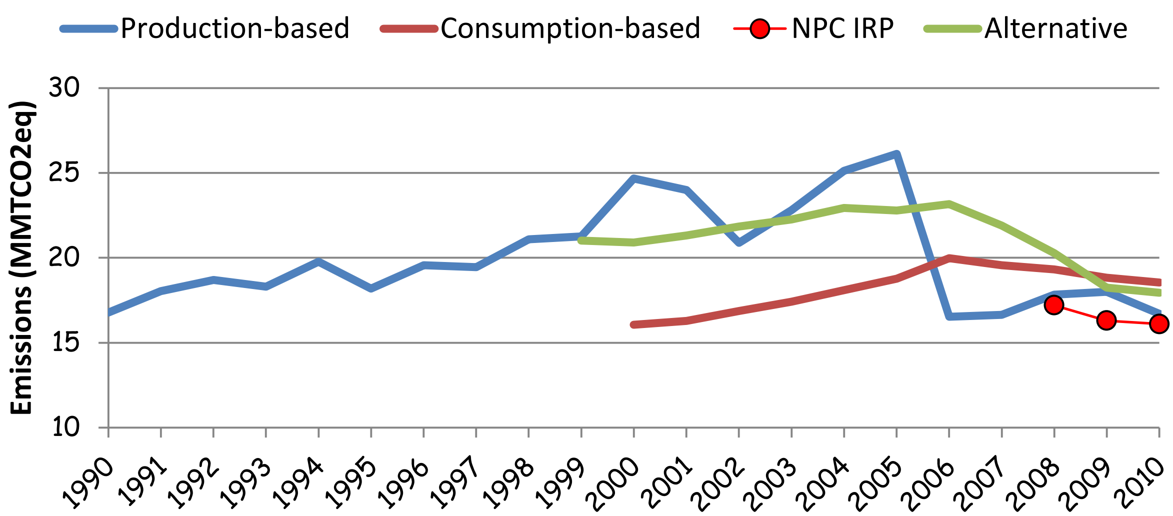


Figure 3.6 shows the GHG emissions as estimated using the alternative method and, for comparison, the emissions estimated using the production- and consumption-based methods, as well as the emissions reported by Nevada Power Company (NPC) in the 2012 IRP for both NPC and Sierra Pacific Power Company (SPPC). These two companies are now under NV Energy, but historically they reported to US-EIA and US-EPA separately. Noticeably, all methods seem to converge in their estimates after 2007, but

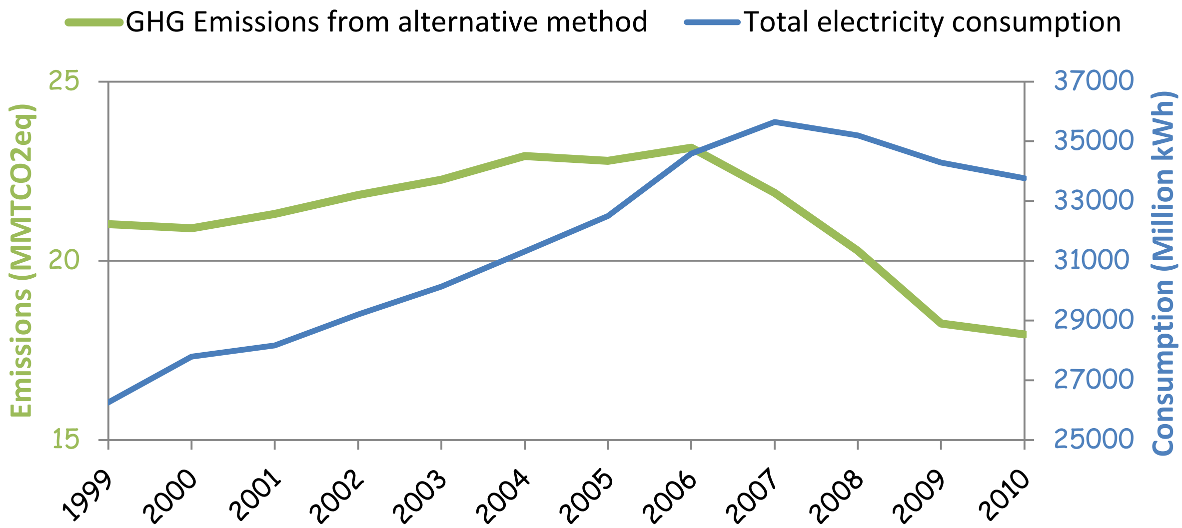
they differed significantly in both their magnitude and patterns before this year. The consumption-based method consistently reported lower emissions for the entire period, which is consistent with the lower emission rates used to convert electricity consumption to GHG emissions (see Figure 11.3 in Section 11.1). The production-based method provides the highest emission estimates until 2005-2006 when, because of the closure of Mohave Generating Station and consequent reduction in coal consumption, a sudden drop in emissions was recorded. While this approach quantifies the actual use of fossil fuel for energy production in Nevada, it does not necessarily reflect the use of fossil fuel to support electricity consumption in Nevada. Figure 3.1 clearly shows that electricity consumption was constantly increasing until the beginning of the economic downturn in 2008. This pattern is more consistent with the emissions estimated using the alternative method (Figure 3.6).

Figure 3.6: GHG Emissions for the power industry as estimated using the different method presented in this report. The 'NPC IRP' is the GHG emissions as reported by the Nevada Power Company in its 2012 Integrated Resource Plan submitted to the Public Utility Commission of Nevada (only from 2008 to 2010).



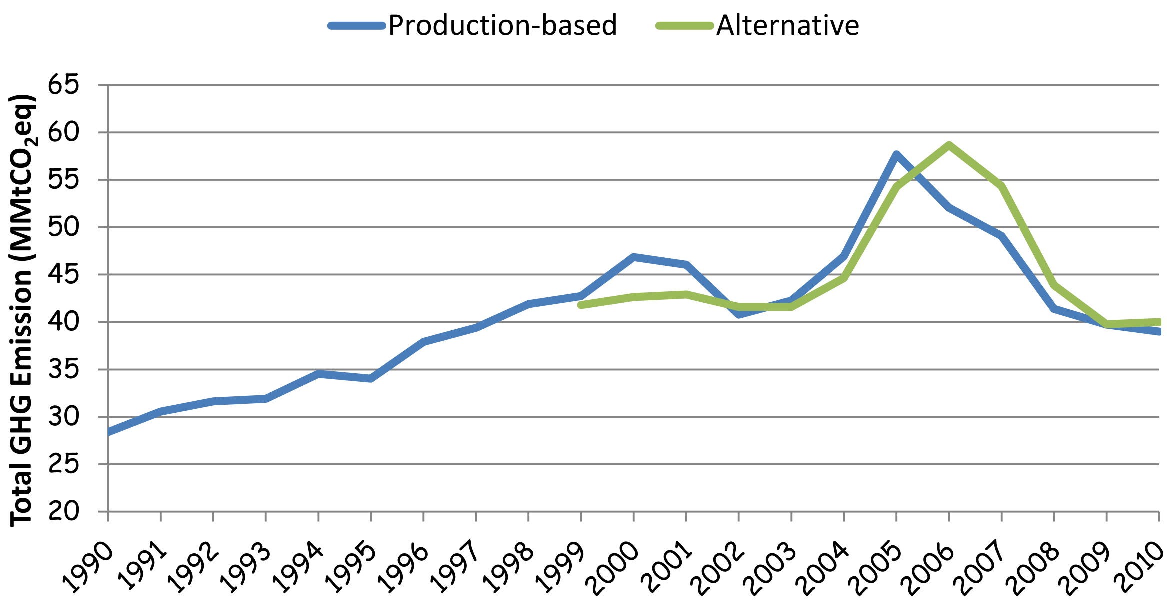
However, even in this case, some differences can be noticed. In particular, while electricity consumption increased at constant pace through 2007 (Figure 3.1 and Figure 3.7), emissions showed a slow-down in their increase, in particular for the period 2004-2006(Figure 3.6 and Figure 3.7, green line). This seems to be the result of declining emission rates (i.e., less GHG emitted per unit of fossil fuel burned, Figure 11.3 in Section 11.1) which could partially offset the increase in electricity consumption.

Figure 3.7: GHG emissions from the alternative method (see also Figure 3.6) and total electricity consumption (see also Figure 3.1) from 1999 to 2010. Decline in emission rates for electricity generation may be the reason for the slowdown in GHG emissions despite a constant increase in electricity consumption before 2006. The large drop in emissions in 2006 was caused by the decommissioning of the Mohave Generating Station (coal based). The further decline in both electricity consumption and GHG emissions was likely the result of the economic downturn.



Finally, the decline in emission rates is observable only for the electricity generated in Nevada (NPC and SPCC in Figure 11.3 in Section 11.1), but not for the electricity imported from other states (NWPP, AZNM, and WECC in Figure 11.3), which is characterized by constant emission factors for the entire 1999-2010 period. Figure 3.8 shows total statewide GHG emission as estimated using the production-based (as in Figure 2.1) and the alternative method. Overall, differences are not very large, but by using the alternative method, the peak of emissions is reached in 2006 rather than 2005. This is probably the results of several concurrent factors: a) the alternative method is not expected to be sensitive to the decommissioning of Mohave's Generating Station, which was mainly exporting electricity out-of-state (hence, did not account Mohave's GHG emissions as part of Nevada's total emissions); b) the alternative method, however, responds to changes in electricity consumption in Nevada, which started declining in 2007; c) with the alternative method, the larger-than-average emission of GHGs due to wildfires in 2006 (see Section 10) was not offset by the reduction in emissions due to the decommissioned Mohave's Generating Station, and therefore the former largely contributed to the peak in GHG emissions in the same year.

Figure 3.8: Total statewide GHG emissions as estimated using the production-based method (EPA-SIT 2012 recommended, as also shown in Figure 2.1) and the alternative method presented in this section.



Indeed, simplifications are introduced with the alternative method, in particular: the use of an 'average' emission rate for the intrastate electricity generation, another emission rate for the imported electricity, and the estimates of losses due to electricity transmission. Nevertheless, this method represents an objective and reliable way to reconcile production- and consumption-base estimates of GHG emissions for Nevada.

3.3 Projected Emissions

The Annual Energy Overlook 2012[12] projects for U.S. and for the period 2010-2035:

"[…]*continued modest growth in demand for energy over the next 25 years and increased domestic crude oil and natural gas production, largely driven by rising production from tight oil and shale resources. As a result, U.S. reliance on imported oil is reduced; domestic production of natural gas exceeds consumption, allowing for net exports; a growing share of U.S. electric power generation is met with natural gas and renewables; and energy-related carbon dioxide emissions remain below their 2005 level from 2010 to 2035, even in the absence of new Federal policies designed to mitigate greenhouse gas (GHG) emissions*"

In the 2008 Nevada Statewide GHG Emissions Inventory and Projections[1], seven scenarios were considered in estimating projected emissions for the period 2008-2020. These seven scenarios were different combinations of generation plant retirements and additions and were based on the Nevada Power Company IRP. Details can be found in Section 11.1.2, but in general, all these scenarios included at least the addition of a new coal-based power plant, and one of them simulated the addition of three

[12] http://www.eia.gov/forecasts/aeo/chapter_executive_summary.cfm

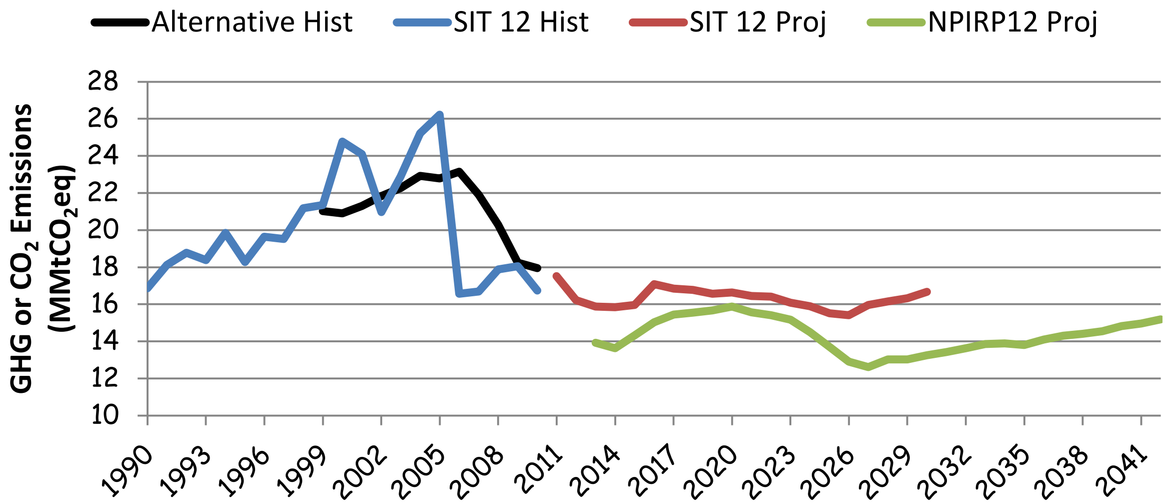
new coal power plants. None of the new power plants considered in the scenarios were built. In retrospect, the scenario based on the Nevada Power Company IRP, which forecasted the least change in the power generation grid (i.e., decommissioning of the Mohave Generating Station and Reid Gardner units 1-3 still active), was the most accurate.

In this report, projected GHG emissions from 2011 to 2030 were estimated using the Projection Tool of the EPA-SIT 2012. This method is based on the projected regional energy consumption from the EIA Annual Energy Outlook 2011. Regional consumptions are disaggregated to state-level by applying the proportion of consumption recorded in 2009. This method can well reproduce GHG emissions at national and regional scales. However, the down-scaling of this approach to smaller scales, like states, may not correctly predict local economic and energy-consumption dynamics, and its projections may be more uncertain. For this reason, this report includes both the SIT12 projections and the future CO_2 emissions estimated and reported in the Nevada Power Company's 2012 IRP (NPIRP12) and submitted to the Public Utility Commission of Nevada[13]. The NPIRP12 bases its 2013-2042 projections on the same model adopted by EIA for national and regional consumption (though using the EIA- Annual Energy Overlook for 2012, rather than 2011's) , but allocates electricity production and purchase following economic and development criteria specifically targeted to Nevada's electricity demand. In particular, NPIRP12 considers four alternative cases which include electricity production, and hence CO_2 emissions, for both Nevada Power Company (NPC) and Sierra Pacific Power Company (SPPC). These four cases include power purchase agreements and various generation projects in terms of types, capacities, and timelines (starting from 2018). However, differences in CO_2 emissions resulting from the adoption of any of these cases are minimal (max 2% between cases at any time). For this reason, only the average CO_2 emissions from all the four cases are shown in this report. Figure 3.9 shows both historical and projected emissions. Historical emissions are shown from both SIT12 and the alternative method (from section 3.2.3). Projections are shown from both SIT12 and NPIRP12. Both projections have similar patterns, though their absolute numbers are slightly different. In general, the modest growth in electricity demand and the increasing use of natural gas over coal is expected to cause overall flat GHG emissions for most of the projected period. Both methods forecast a small increase in emission from 2015, followed however by another decline until 2028. The total emission never reaches the peak observed in 2005-2006 (23-26 $MMtCO_2eq$), rather it averages around 14-16 $MMtCO_2eq$ for the 2010-2030 period.

As mentioned above, NPIRP12 only reports CO_2 emissions (not total GHGs). However, an analysis of the historical contribution of all non-CO_2 GHGs (CH_4 and N_2O) in the power generation sector showed that this is not higher than 0.5%, making the comparison between SIT2012 and NPIRP12 fairly appropriate and accurate.

[13] http://pucweb1.state.nv.us/PUCN/DktInfo.aspx, docket number 12_06053, Vol. 19

Figure 3.9: Historical and projected emissions from the power generation sector. For the historical emissions, the SIT2012 (SIT12 Hist) and the emissions estimated using the alternative method (Alternative Hist) are shown. For the projected emissions, both the SIT 2012 projections (SIT12 Proj) and those reported in the Nevada Power Company 2012 IRP (NPIRP12 Proj) are shown. However, NPIRP12 only reports total CO_2 emissions (not total GHGs) for both Nevada Power Company and Sierra Pacific Power Company.



4 Residential, Commercial, and Industrial Sector Emissions

4.1 Overview

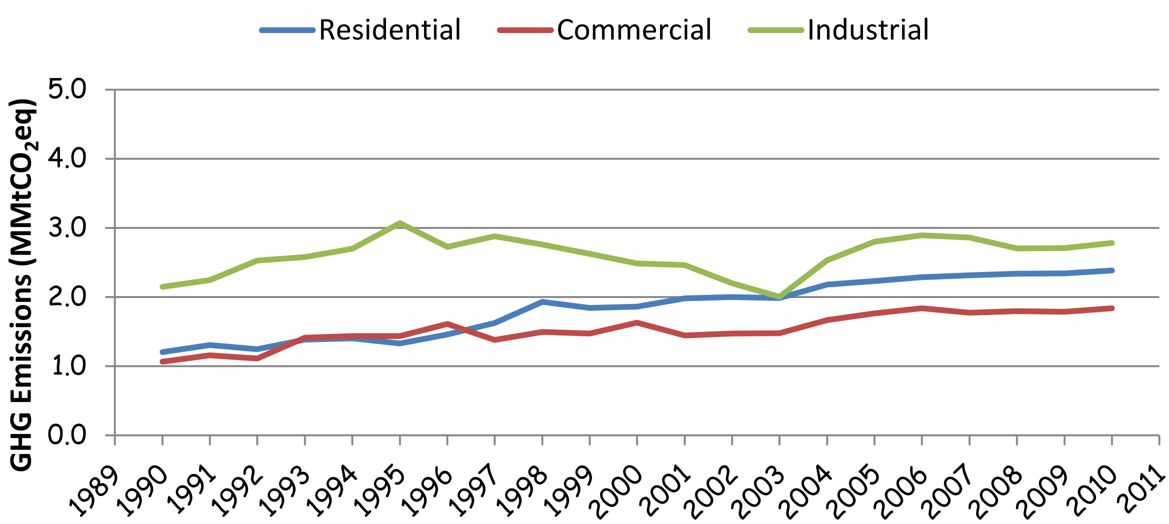
This section includes all the stationary GHG emissions from fossil fuel burning in the residential, commercial, and industrial sectors. The main GHGs released are primarily CO_2, CH_4, and N_2O. Emissions are generally accounted for by applying specific emission factors (expressed in mass of carbon per unit of energy content, e.g., lbs/BTU) and combustion efficiency (expressed in percentage) to different types of fossil fuels consumed in each sector. Industrial emissions also need to be adjusted for the amount of carbon that is not released into the atmosphere but rather used in non-energy industrial processes that store carbon permanently (like for instance, in the case of asphalt and road oil). Emission factors, energy content, combustion efficiency, and fraction of non-energy use by fuel type and sector were provided by US EPA SIT 2012. Fuels consumption was provided by US EIA-SEDS.

4.2 Historical Emissions

Residential, commercial, and industrial emissions (RCI) accounted for about 13% of total statewide GHG emissions in 1990, and about 16% in 2010 (Figure 2.3). Total RCI emissions were 4.4 MMtCO_2eq in 1990 and increased up to 7.0 MMtCO_2eq in 2010 (

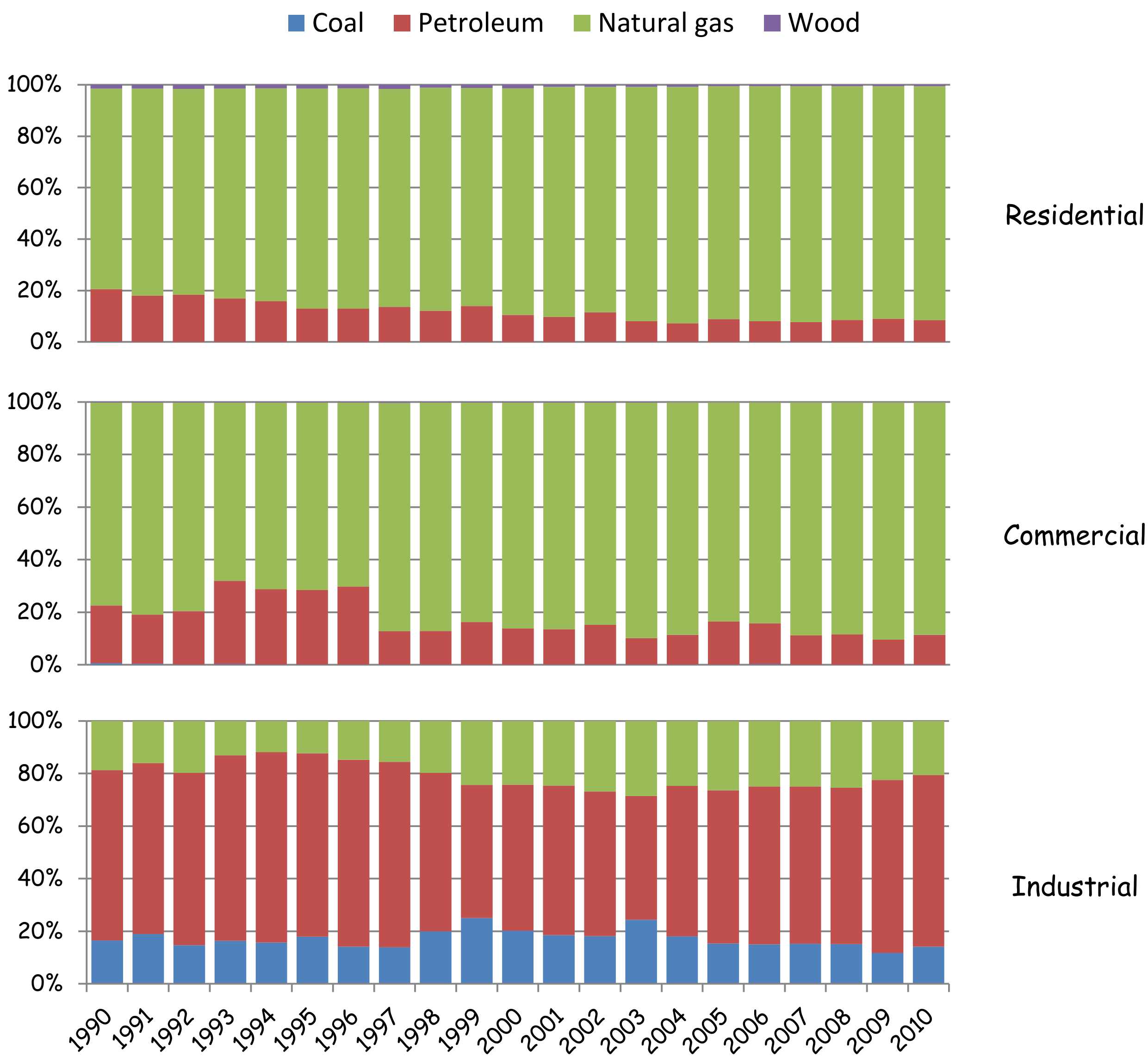
Figure 4.1).

Figure 4.1: Historical GHG emissions for the residential, commercial and industrial (fuel use only) sectors.



Emissions from this sector are dominated by CO_2 (more than 99%). Each fossil-fuel type contributed differently to each sector's GHG emissions (Figure 4.2). Natural gas was the largest source of emission in both the residential and commercial sectors (around 80%), while petroleum (around 20%) historically showed a small but consistent declining trend. Petroleum was the largest source of emission in the industrial sector (around 60%) followed by coal and natural gas (around 20% each). In this case, fluctuations in the relative contribution to emissions can be observed between 1990 and 2010, but no clear trends are detected.

Figure 4.2: Relative contribution (percentage) of each type of fuel to total GHG emissions for each economic sector. Not all fuel types appear in each sector graph, as their contribution may be negligible.



4.3 Projected Emissions

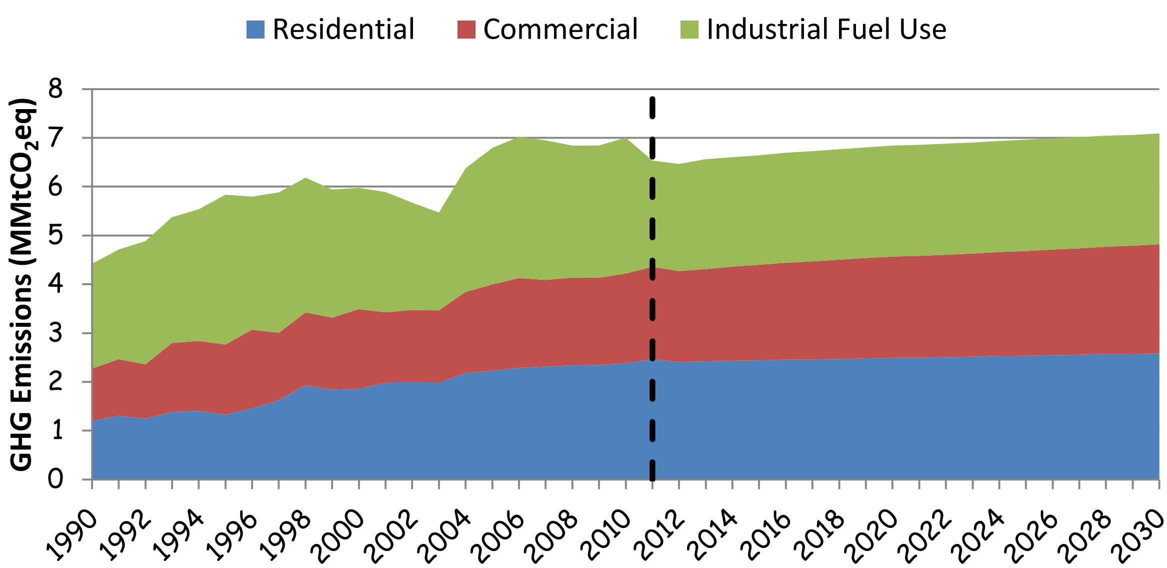
Projections for the RCI emissions were based on the DOE-EIA Energy Outlook 2011[14] for the period 2009-2035. The EIA projections are based on the National Energy Modeling System (NEMS), an energy-economy modeling system, which is based on assumptions, among others, on macroeconomic and

[14] http://www.eia.gov/forecasts/archive/aeo11/topic_macroeconomic.cfm

financial factors, world energy markets, resource availability and costs, and demographics[15]. Projections of fuel consumptions were estimated at census division scale (Mountain census division for Nevada) and redistributed across states based on the 2009 state consumptions. The Energy Outlook 2011 (reference case) predicts a gross domestic product (GDP) average increase rate of 2.7% nationwide, a nonfarm employment average increase rate of 1.0% nationwide for the Mountain census division. These macroeconomic projections do not substantially differ from the DOE-EIA Energy Outlook 2012[16] and from the average employment growth rate of 1.1% estimated for Nevada during 2010-2020 by the Nevada Department of Employment Training and Rehabilitation (DETR[17]). In terms of population growth, US-EIA predicts an average rate of 1.0% nationwide between 2010 and 2035, similar to the 1.1% predicted by the Nevada State Demographer for Nevada from 2010-2030.

Figure 4.3 shows historical and projected GHG emissions by RCI sectors and for the period 1990-2030. Total emissions are estimated to top 7 $MMtCO_2eq$ by 2030, which represents an increase of about 60% from 1990, but virtually no difference with 2010.

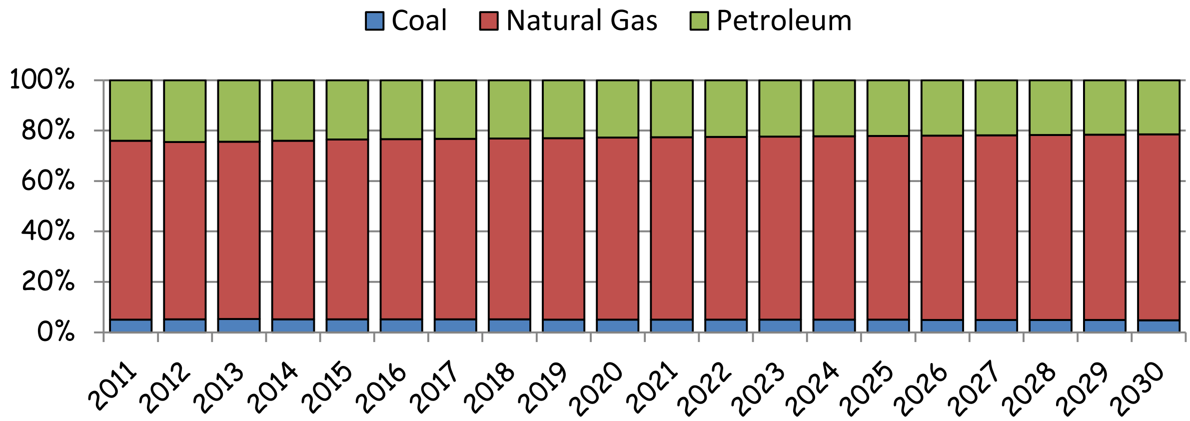
Figure 4.3: Historical and projected GHG emissions for each RCI economic sector and for the period 1990-2030. The vertical dashed line marks the end of historical data and the beginning of projections.



Natural gas is projected to be the largest contributor of GHG emissions in the RCI sectors (from over 60% of total emissions in 2010 to about 74% in 2030). Petroleum is the second largest contributor, around 24-21%, followed by coal, around 5% (Figure 4.4).

[15] The National Energy Modeling System: An Overview 2009, http://www.eia.gov/FTPROOT/forecasting/05812009.pdf
[16] http://www.eia.gov/forecasts/aeo/
[17] http://www.nvdetr.org/

Figure 4.4: Projected contribution on total GHG emissions for each fuel type for the period 2011-2030. Only coal, natural gas, and petroleum are shown, as other types of fuels (e.g., wood) are negligible (i.e. less than 0.5%)



5 Transportation Sector Emissions

5.1 Overview

Historically, the transportation sector has been a consistent and significant source of GHG emission in Nevada (Figure 2.1 and Figure 2.3), second only to the power generation sector. However, in light of only a moderate increase in electricity demand and a switch to either fossil fuels that emit relatively less CO_2 (for example from coal to natural gas) or renewable energy sources, this sector may soon become the largest GHG emitter in the state. Historical emissions for the transportation sector were calculated based on the preferred method in the EPA-SIT 2012. GHGs emitted by this sector are CO_2, CH_4, and N_2O. CO_2 emissions, which constitute 99% of total GHG emissions of this sector, are the result of fossil fuel combustion and can be directly related to the type of fossil fuel and the total amount combusted. There is no CH_4 in either gasoline or diesel, but CH_4 emission is generated as a result of the combustion process and influenced by fuel type, combustion conditions (e.g., vehicle type, age, etc…), and control technologies. Emission of N_2O by transportation is not completely understood, but like for CH_4, the amount of N_2O released is dependent on the type of combustion process. The EIA-SEDS provides fuel consumption for the transportation sector at a state level. This data is used to determine CO_2 emissions. In order to quantify N_2O and CH_4 emissions, the type and conditions (e.g., age) of vehicles, the type of fuel, and the mileage traveled are needed. The total mileage traveled by vehicles each year (Annual Vehicle Miles of Travel, AVMT) was obtained from the Nevada Department of Transportation[18] and disaggregated into different vehicle categories and classes of age using national averages. It is possible that using the national averages may have resulted in additional uncertainty in the emission estimates for the transportation sector, as Nevada's distribution of vehicle types and ages may differ from the national average. However, CH_4 and N_2O emissions account for less than 5% of total GHG emissions from the transportation sector (less than 2% between 2007 and 2010), and therefore the potential error is most likely very small.

5.2 Historical Emissions

Figure 5.1 shows the vehicle miles traveled (VMT), the historical GHG emissions for the transportation sector (top), and Nevada population from 1990 to 2010 (bottom). There is a clear dependency between population growth, VMT, and GHG emission from 1990 to 2006. This suggests that the main factor affecting GHG emissions in the transportation sector was population growth. However, this correlation disappears in 2007, when despite Nevada's population showing a slight increase, both VMT and GHG emission sharply decline until 2009. Evidence, including statistics at the national level, points to a significant reduction in VMT starting from 2007 as a result of the economic downturn[19,20].

[18] http://www.nevadadot.com/About_NDOT/NDOT_Divisions/Planning/Roadway_Systems/Annual_Vehicle_Miles_of_Travel.aspx

[19] http://www.ssti.us/2012/02/motor-vehicle-travel-demand-continues-long-term-downward-trend-in-2011

[20] http://www.bts.gov/publications/bts_transportation_trends_in_focus/2010_04_01/html/entire.html

Data from the Nevada Department of Motor Vehicles[1] point to an increase in VMT in 2009 but not to an equivalent increase in GHG emissions (Figure 5.1). This suggests that cleaner and more fuel efficient vehicles are replacing dirtier ones, but also that fuel price may play a role in determining motorist shifts to alternative practices, such as mass transit, carpooling, and other alternatives. This is further corroborated by Figure 5.2.

Figure 5.1: Total GHG emissions and vehicle miles traveled (VMT) from the transportation sector (top) and population in Nevada from 1990 to 2010 (bottom).

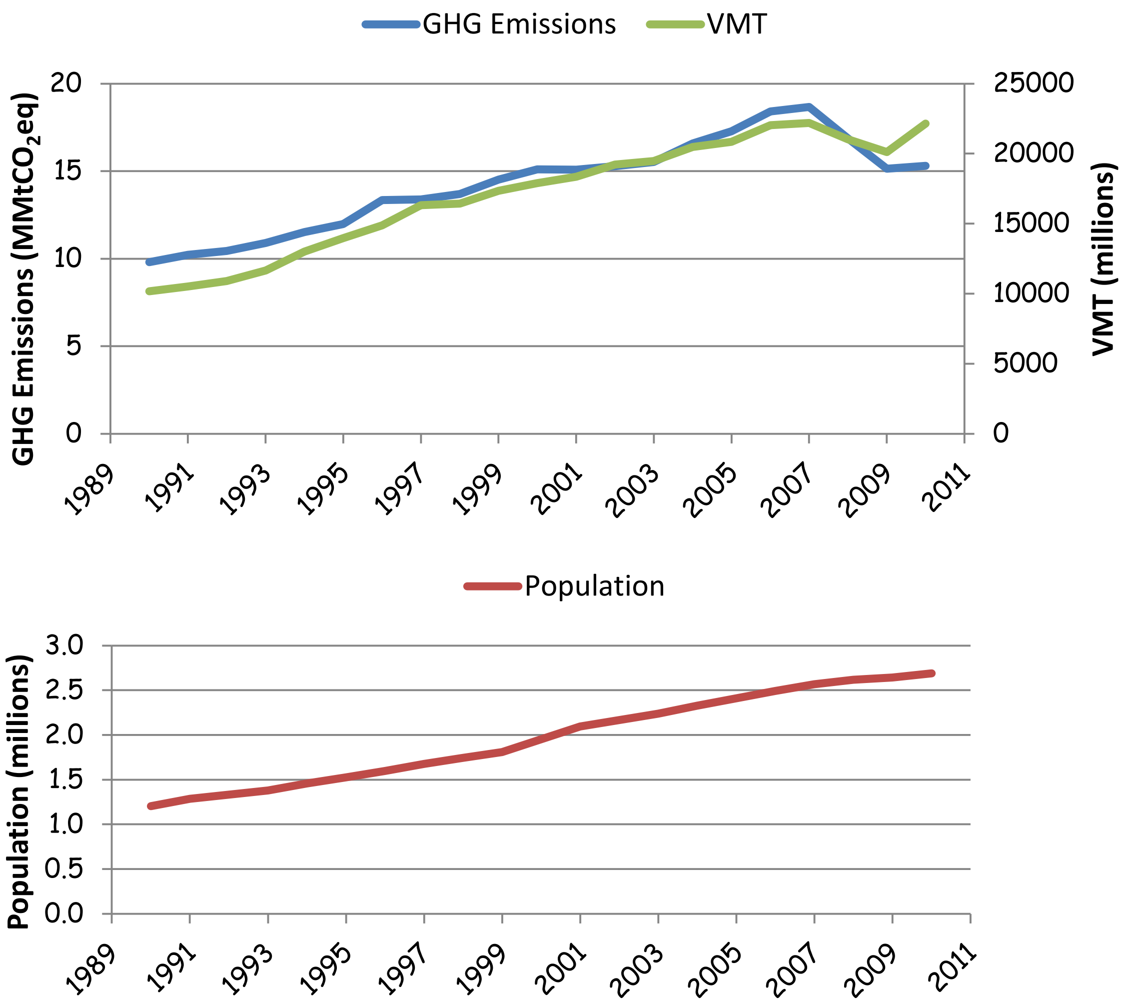
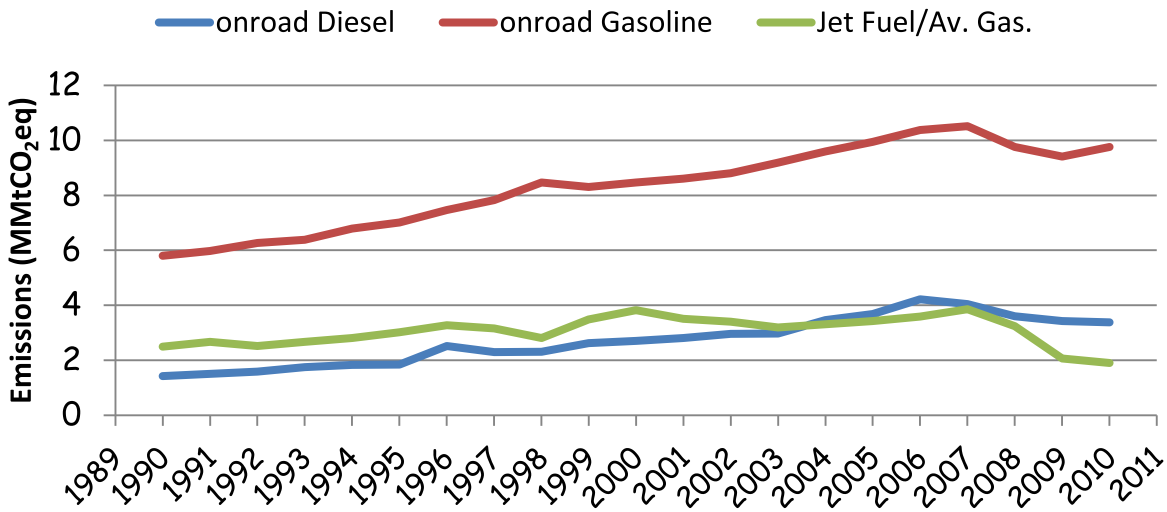


Figure 5.2 shows GHG emissions disaggregated by the three major fuels used in the transportation sector (i.e., diesel and gasoline on-road and fuel for aviation, covering more than 99% of total emissions in the transportation sector). Similarly to what is seen for VMT and GHG emissions, the decline in 2007, likely caused by the economic downturn, is evident in all three datasets. A clear difference in patterns, however, appears between the emissions caused by gasoline consumption and emissions from diesel and aviation fuel. The former showed a recovery trend starting in 2009, while the other two were either

flat or showed a decline. This pattern, together with the fact that gasoline vehicles are in general more efficient, may explain the apparent contradiction of constant GHG emissions under increasing VMT in 2009 and 2010 (Figure 5.1 and additional analysis in Section 11.2 and Figure 11.4).

Figure 5.2: GHG emissions disaggregated by the three major fuels consumed in the transportation sector. Other types of fuels are not included as their contribution is negligible (i.e., less than 1%)



5.3 Projected Emissions

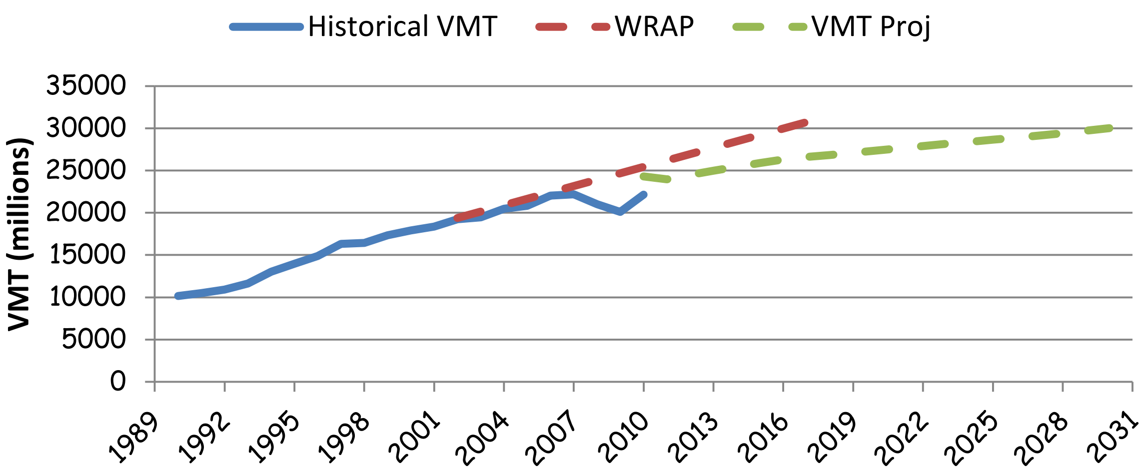
Projected fuel consumption by the transportation sector for the period 2011-2030 was obtained by US-EIA, which provides projections for every five years. Linear interpolation was used for the intermediate years. Total VMT was calculated based on estimates of fuel consumption per mile travelled (MPG), and disaggregated by vehicle type and age using a weighted average approach. These proportions did not change from year to year. The percentage of the most advanced emission control technologies by vehicle type was assumed to increase by 5% for each year.

As a reference, the VMT projections estimated in the Western Regional Air Partnership (WRAP) mobile source emission inventory is included[21]. This report was based on VMT estimates for 2002 and produced estimates of VMT and air quality standard emissions (hence non GHGs) up to 2018. The results from the WRAP report were considered more locally driven than the EIA estimates and were used to adjust projected transportation emissions in the 2008 Nevada GHG Report[22]. However, the models used for the WRAP estimates could not include the effects of the 2007 economic-downturn, which, as seen in the previous section, caused a significant decline in transportation activity at both the national and local level, and also a potential shift in the proportion of vehicle and fuel type consumed in the transportation sector (see Section 11.2 and Figure 11.4 for additional analysis and information). Furthermore, a strong correlation exists between Nevada population and VMT for the 1990-2006 dataset (see Section 11.2 and Figure 11.5 for more details). It is likely that the lower population growth rates predicted for the next 20

[21] 2006 update, http://wrapair.org/forums/ef/UMSI
[22] Nevada Statewide Greenhouse Gas Emissions Inventory and Projections, 19920-2020

years[23] will contribute to reducing projected VMT growth (and therefore GHG emissions) as well. Figure 5.3 shows the projected VMT for Nevada as derived using the relationship with population growth (Figure 11.5), together with WRAP projections, and historical estimates. It is evident that the economic downturn strongly affected the VMT trends. Actual VMT were about 20% less than that projected by WRAP. Also, WRAP estimated an average annual VMT growth of about 3% (similar to the VMT growth rate observed in the period 1990-2006). Based on more recent population growth estimates, VMT will not increase more than 1% annually[23].

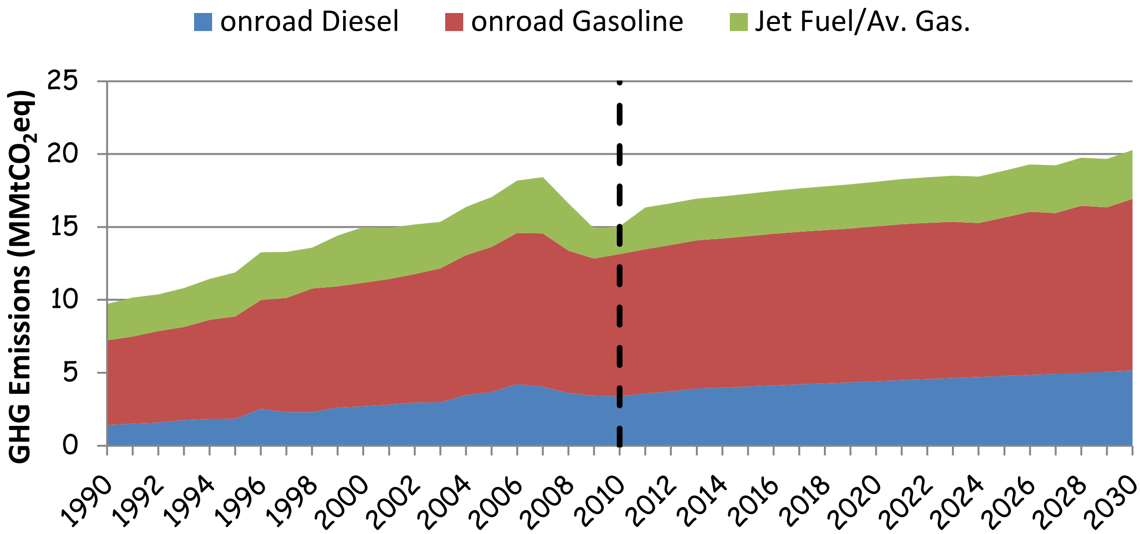
Figure 5.3: Historical vehicle miles travelled (1990-2010) and projected VMT from the Western Regional Air Partnership mobile source emission inventory (WRAP) using current projected population growth for 2011-2030 (VMT Proj). VMT Proj was based on the relationship between population and VMT developed for Nevada using the years from 1990-2006 (Figure 11.5), hence excluding the effects of the 2007 economic downturn. Details of this method can be found in Section 11.2). WRAP estimates are here displayed with a line connecting 2002 estimates and 2018 projections. The actual WRAP projections follow a slightly different, non-linear, pattern between 2002 and 2018, but this difference is negligible and does not affect any of the considerations and conclusions presented in this report.



Overall, GHG emissions for the transportation sector from 2011-2030 will continue to increase but with a relatively lower pace than what was observed for the 1990-2010 period (Figure 5.4). Projections for the year 2030 indicate that total emissions for transportation will reach 20 $MMtCO_2eq$, with onroad gasoline accounting for about 25% of total emissions (from 22% in 2010), onroad diesel for 57% (from 64% in 2010), and jet fuel and aviation gasoline for 16% (from 12% in 2010). Other sources of GHGs will remain negligible (i.e. less than 1%). Future developments in technology, such as a switch to plug-in electrical automobiles, could alter emissions projections for this sector. These trends, however, are driven by price, consumer preference, and rate of technical advancement that are difficult to forecast.

[23] data from the Nevada State Demographer, http://nvdemography.org/

Figure 5.4: Historical and projected GHG emissions for the transportation sector disaggregated by major fuel types (covering more than 99% of total emissions). The vertical dashed line marks the end of historical emissions and the beginning of projections.



6 Industrial Process Sector Emissions

6.1 Overview

This section presents estimates of GHG emissions from non-energy related industrial process (IP). In these activities, transformation of raw materials from one state to another results in the release of GHGs in the atmosphere such as CO_2, N_2O, hydrofluorocarbons (HFC), perfluorinated carbons (PFC), and sulfur hexafluoride (SF_6). The following table lists the industrial activities that were considered in this report, the associated type of GHG emissions, and a brief description of sources and methodologies used to estimate GHG emissions.

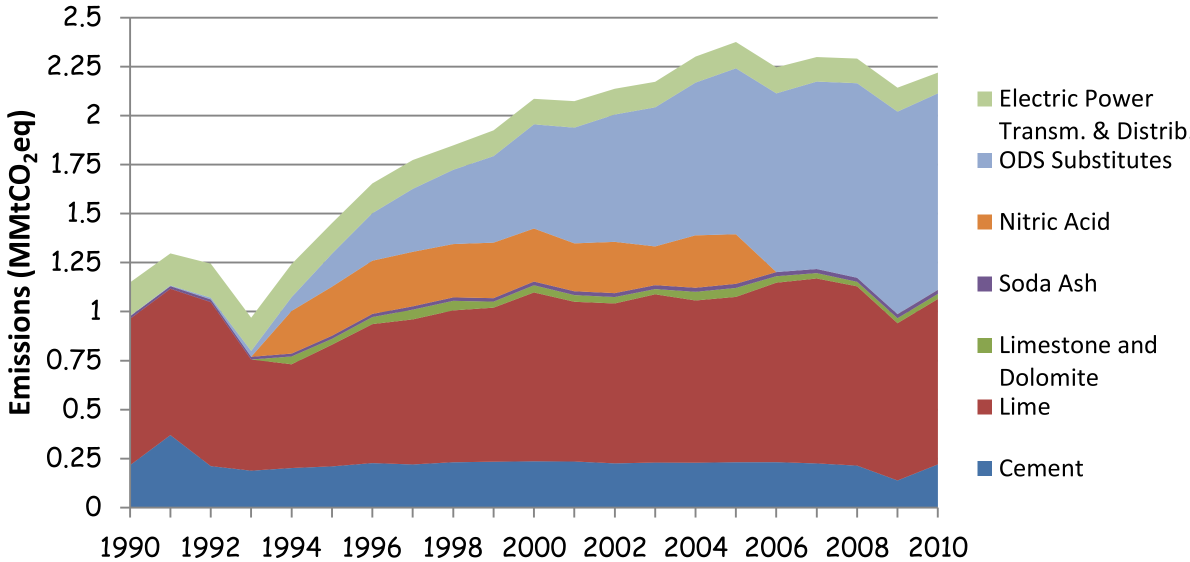
Table 6.1: Industrial activities considered in this report, including those that are not present in Nevada and for which no data were available

Activity	Associated GHG emissions	Data Required	Data Source
Cement Manufacture	*CO_2*	*Emission factors and production data for clinker and cement kiln dust*	*SIT 2012 NV GHG Emission Inventory (2008) USGS Minerals Yearbook EPA GHG Inventory 2010*
Lime Manufacture	*CO_2*	*Emission factors and production data for high-calcium lime and for dolomitic lime*	*SIT 2012 NV GHG Emission Inventory (2008) USGS Minerals Yearbook EPA GHG Inventory 2010*
Limestone and Dolomite Use	*CO_2*	*Emission factors and consumption data for limestone, dolomite, and magnesium produced from dolomite*	*SIT 2012 USGS Minerals Yearbook EPA GHG Inventory 2010*
Ammonia production & Urea consumption	*CO_2*		*SIT 2012*
Soda Ash Consumption	*CO_2*	*Emission factors and consumption data for ash*	*SIT 2012 USGS Minerals Yearbook US Census and NV Census*
Nitric Acid Production	*N_2O*	*Emission factor, production data, and percent N2O Released after pollution control for nitric acid production*	*SIT 2012 NV GHG Emission Inventory (2008) EPA GHG Inventory 2010*
Ozone Depleting Substance Substitutes (ODSS)	*HFC, PFC, SF_6*	*National emissions, state and U.S. population*	*SIT 2012 US Census and NV Census EPA GHG Inventory 2010*
Semiconductor Manufacturing	*HFC, PFC, SF_6*	*National emissions, Economic Census*	*SIT 2012 EPA GHG Inventory 2010*
Electric Power Transmission and Distribution Systems	*HFC, PFC, SF_6*	*Emission factor and national SF6 consumption data for electric power transmission and distribution. Electricity sales at national and state level*	*SIT 2012 DOE – EIA*
Activities not present in Nevada			
Iron & Steel Production	*CO_2*		
Adipic Acid Production	*N_2O*		
Aluminum Production	*HFC, PFC, SF_6*		
Activities for which no data were available			
Magnesium Production	*HFC, PFC, SF_6*		
HCFC-22 Production	*HFC, PFC, SF_6*		

6.2 Historical Emissions

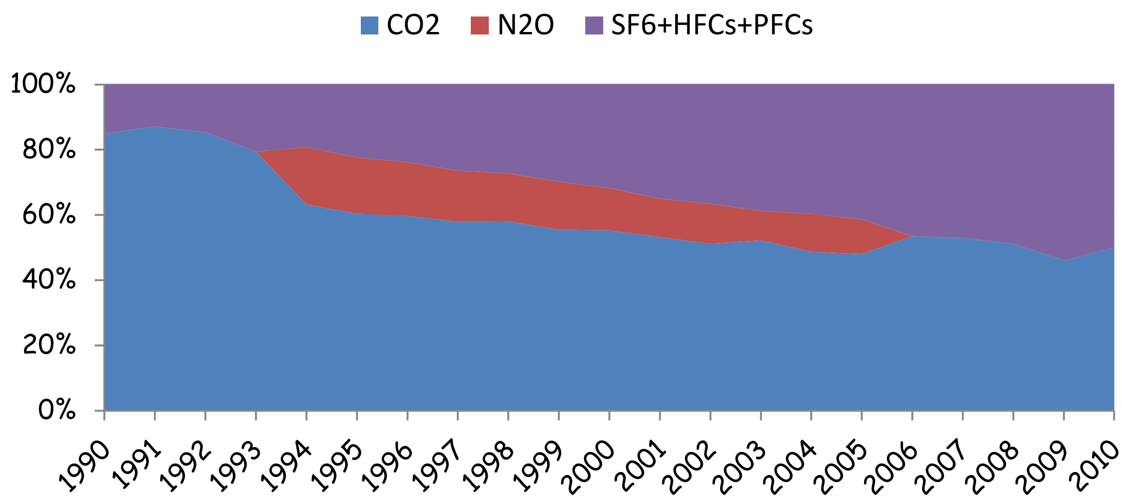
IP emissions represents about 3-5% of total GHG emissions in Nevada. IP emissions sharply increased from 1990, rising from 1.25 to almost 2.25 MMtCO$_2$eq (80% of increase, Figure 6.1). However, this large change was mostly driven by a sharp increase in ozone depleting substance substitute (ODSS) emissions starting in the mid-90's; in 1990 there were virtually no ODSS-related emissions, but in 2010 they accounted for about 45% of total IP emissions. Hydrofluorocarbons (HFCs), which are one of the most powerful GHGs, are used primarily as alternatives to several classes of ODSs phased out under the terms of Montreal Protocol (1987) and the Clean Air Act Amendments of 1990. Lime production represented the second source of GHG in Nevada (approximately 1.0 MMtCO$_2$eq, 50% of IP emissions in 2010) followed by cement manufacture with about 0.25 MMtCO$_2$eq emitted every year.

Figure 6.1: GHG emissions from non-energy related industrial processes (IP). Emissions from ammonia production and urea consumption, and semiconductor manufacturing are not shown, as their contributions to total IP emissions are negligible.



Carbon dioxide contributed for more than 80% of GHG emissions in this sector in the early 90's. However, as the use of ODSS increased in the mid 90's, the aggregate contribution of GHGs such as SF$_6$, HFCs, and PFCs went from approximately 10% to almost 50% (Figure 6.2).

Figure 6.2: Relative contribution of each GHG type to total emissions in the industrial process sector.



6.3 Projected Emissions

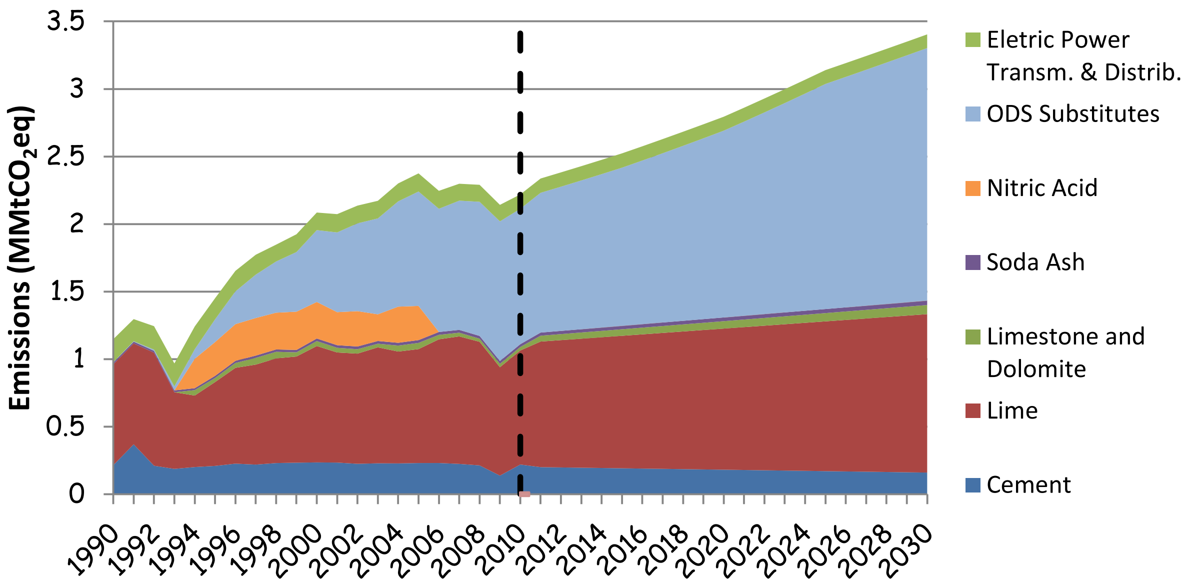
Table 6.2 describes the approach and data source used to project emissions for each of the activities described in the previous section. In general, trends for the period 1990-2010 were used to project emissions for 2011-2030, as also recommended by SIT 2012, in particular when local data or more detailed analyses are not available. However, in some cases, different and/or alternative approaches were adopted and compared. More details and analyses can be found in Section 11.3.

Table 6.2: Approaches and data sources used for the IP emission projections

Activity	Approach	Data Source
Cement Manufacture	• *1990-2010 trends* • *(2010-2020) Growth rate from Nevada Department Employment*	*SIT 2012* *Nevada Department of Employment*
Lime Manufacture	• *1990-2010 trends* • *(2010-2020) Growth rate from Nevada Department Employment*	*SIT 2012* *Nevada Department of Employment*
Limestone and Dolomite Use	• *1990-2010 trends* • *(2010-2020) Growth rate from Nevada Department Employment*	*SIT 2012* *Nevada Department of Employment*
Ammonia production & Urea consumption	*1990-2010 trends*	*SIT 2012*
Soda Ash Consumption	• *1990-2010 trends* • *2.25% annual growth*	*SIT 2012* *USGS Minerals Yearbook 2010*
Nitric Acid Production	*Assumed to be 0*	*SIT 2012*
Ozone Depleting Substance Substitutes (ODSS)	• *1990-2010 trends* • *Variable % annual growth*	*SIT 2012* *2011 EPA Non-CO_2 GHG Report 2010-2030*
Semiconductor Manufacturing	• *1990-2010 trends*	*SIT 2012*
Electric Power Transmission and Distribution Systems	• *1990-2010 trends*	*SIT 2012*

Figure 6.3 shows historical and projected GHG emissions for the IP sector. The most prominent 'feature' of these projections is the constant increase of the ODSS emissions. ODSS emissions will almost double, from 1.0 MMtCO$_2$eq in 2010, to 1.9 MMtCO$_2$eq in 2030. Their contribution to total IP GHG emissions will increase from 45% in 2010 to 55% in 2030. According to the EPA Non-CO$_2$ GHG Report 2010-2030 (2011, draft[24]): "HFC emissions from ODS substitutes are expected to [*globally*] increase by a factor of six between 2005 and 2030, driven by strong demand for refrigeration and air conditioning equipment in developing countries". However, it is important to note that ozone depleting substances are themselves GHGs and more potent than HFCs used as a substitute. It is therefore possible that had the phase-out of ODS not occurred, more warming would have occurred.

Figure 6.3: Historical and projected GHG emissions from non-energy related industrial processes (IP). Emissions from ammonia production and urea consumption, and semiconductor manufacturing are not shown, as their contributions to total IP emissions are negligible. The vertical dashed line marks the end of historical emissions and the beginning of projections.



[24] http://www.epa.gov/climatechange/EPAactivities/economics/nonco2projections.html

7 Fossil Fuel Industry Sector Emissions

7.1 Overview

This section reports CH_4 emissions that are only released during the production, processing, transmission, and distribution of fossil fuel. In Nevada, these are emissions released via leakage and venting from oil and gas fields, processing facilities, and pipelines (for both transmission and distribution). Emissions associated with energy consumed by these processes (CO_2, N_2O, and CH_4) are included in Section 4, Residential, Commercial, and Industrial Sector Emissions. Emissions associated with energy production from fossil fuel combustion are included in Section 3, Electrical Generation Sector Emissions.

Production of both natural gas and oil are marginal in Nevada. Current (2011) oil production in Nevada is about 1,000 barrels per day[25], after peaking in the early 90's at about 10,000 barrels per day. Natural gas production was estimated to be 4 million cubic feet in 2010, after peaking in the early 90's at about 50 million of cubic feet. Nevada's consumption of natural gas was estimated to be about 260,000 million of cubic feet in 2010, while petroleum consumption was about 124,000 barrels per day[26]. Methodologies to estimate GHG emissions were provided by SIT 2012. The dataset used to estimate GHG emissions is summarized in the following table.

Table 7.1: Sources used to estimates GHG emissions in the fossil fuel industry sector

Process	Source	Reference
Emission factors	SIT 2012	
Natural gas production	• Independent Petroleum Association of America – Economic Report & Industry Statistics • US-EIA	http://www.ipaa.org/reports/econreports/index.php http://www.eia.gov/
Natural gas processing	US-EIA	http://www.eia.gov/
Natural gas transmission	U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) –Annual Reports *	http://phmsa.dot.gov/pipeline/library/data-stats
Natural gas distribution	U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) –Annual Reports	http://phmsa.dot.gov/pipeline/library/data-stats
Oil Production	US-EIA	http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_m.htm
Oil Refined	US-EIA	http://www.eia.gov/dnav/pet/pet_pnp_unc_dcu_r50_a.htm
Oil Transported	Assumed to be equal to oil refined	

* *Total length of transmission pipeline was not reported until 2000. For years 1990-1999 it was assumed to be equal to 2000.*

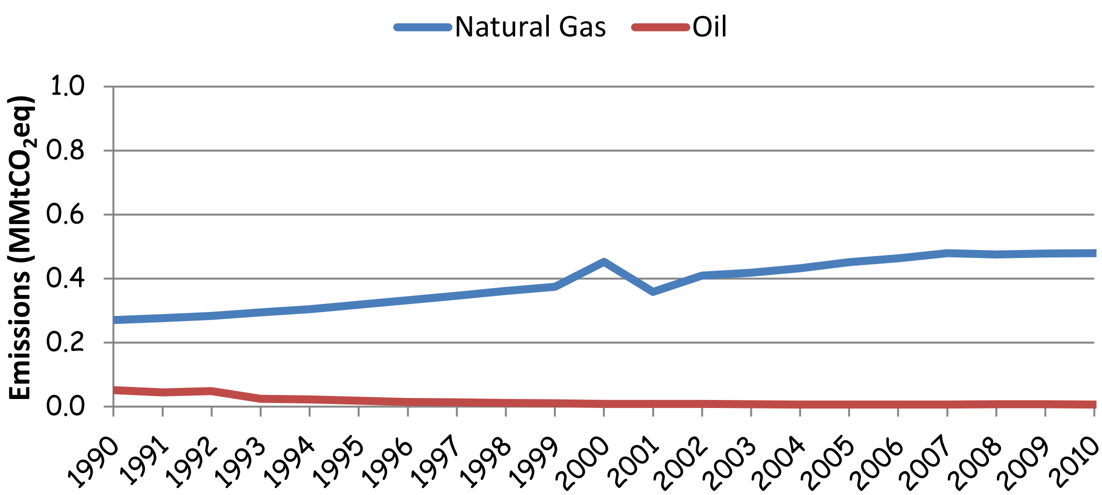
[25] EIA - SEDS, http://www.eia.gov/state/seds/seds-states.cfm?q_state_a=NV&q_state=Nevada#undefined

[26] DOE- EIA, SEDS, http://www.eia.gov/state/seds/hf.jsp?incfile=sep_use/total/use_tot_NVa.html&mstate=Nevada

7.2 Historical Emissions

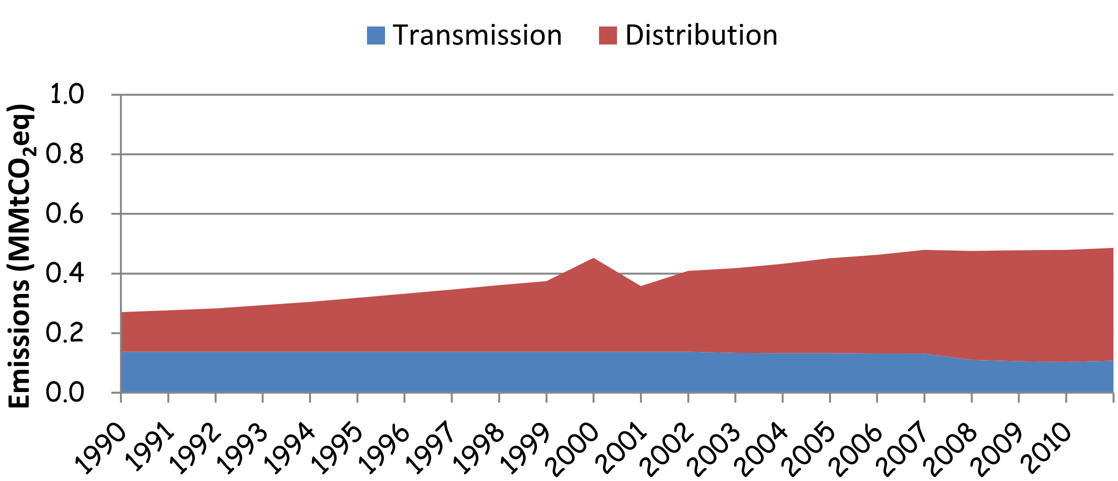
Because of the absence of a coal industry and marginality of natural gas and oil production in Nevada, emissions from production, processing, transmission, and distribution represent a very small fraction of the total GHG emissions of the state. Historically, emissions from the fossil fuel industry represented less than 3% of total emissions, with the relative contribution of natural gas in the sector increasing from 72% in 1990, to 98% in 2010 (Figure 7.1).

Figure 7.1: Historical emissions for the fossil fuel industry, disaggregated by fuel source. Note: data for production, transmission, and distribution of natural gas were not available for 1993 and where estimated by linear interpolation.



Transmission and distribution of natural gas are the major sources of GHG emissions in the sector (Figure 7.2). In 2010, transmission and distribution accounted for 77%, and 21% of total GHG emissions in the sector, respectively.

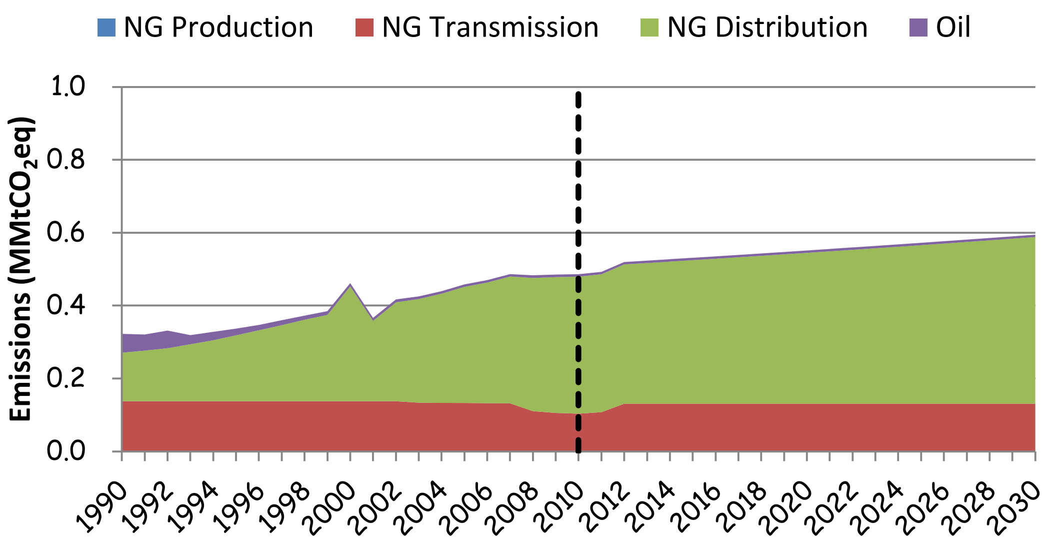
Figure 7.2: GHG emissions due to transmission and distribution of natural gas. Note: data for production, transmission, and distribution of natural gas were not available for 1993.



7.3 Projected Emissions

Emission projections for this sector were based on the assumption that oil and natural gas production will not significantly change in Nevada in the next 20 years. Emissions from oil and natural gas production were kept constant to their 2011 level (the last year of available data). Emissions from natural gas transmission were held constant to the 1990-2011 average. Emissions for natural gas distribution were calculated based on the population increase estimated by the Nevada State Demographer (1% annual increase for the period 2010-2030). This is based on the assumption that the fugitive CH_4 would result from additional gas distribution pipeline needed to serve retail sales (residential, commercial and industrial sector). Based on these assumptions, total GHG emissions from oil and natural gas processes will increase to about 0.6 $MMtCO_2eq$ by 2030, up 24% from 2010. Overall, the marginality of this sector in Nevada's total GHG emissions is confirmed by the 2010-2030 projections as well: total emissions from production, transmission, and distribution of oil and natural gas will contribute only 1% to total GHG emissions in 2030.

Figure 7.3: Historical and projected emissions for oil and natural gas (NG) production, transmission, and distribution. The vertical dashed line marks the end of historical emissions and the beginning of projections.



8 Agriculture Sector Emissions

8.1 Overview

The emissions discussed in this section refer to non-energy emissions from agriculture-related activities. Energy emissions (e.g., combustion of fossil fuels in agriculture equipment) are included in Section 4.

Several processes are included under the agriculture sector, including livestock-, soil-, and crop-related activities. Methane is a natural by-product of animal digestion, in particular ruminants (such as cattle, sheep, and goats), which have higher CH_4 emissions than other types of animals because of their unique digestive process. Manure (i.e., animal waste) management is another important source of CH_4 and N_2O, which are produced during the manure decomposition process. Various agricultural soil management practices contribute to GHG emissions: N_2O is emitted by soil as a result, for instance, of synthetic fertilizer use, application of animal waste and/or crop residue to soil, and direct deposition of animal waste in pastures, ranges and paddocks.

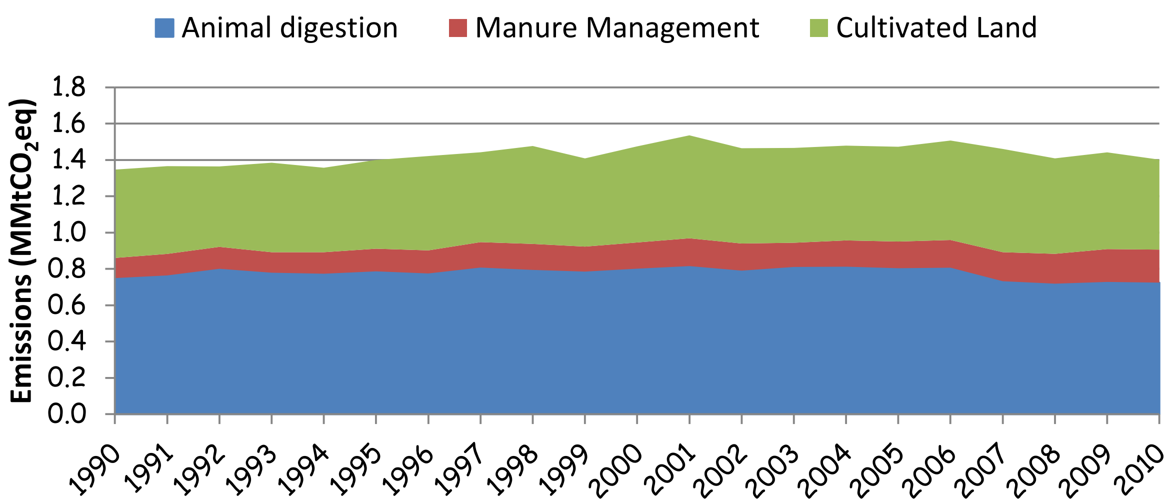
Emissions from the agriculture sector were estimated by relating livestock population statistics, crop production, and fertilizer use with emission factors specific for the several processes and activities considered in this analysis. Emission factors were obtained from SIT 2012, and statistics on livestock and crops for Nevada were obtained from the USDA – National Agricultural Statistics Service (USDA-NASS[27]). At the time this report was compiled, several datasets were not up-to-date to 2010. In these cases, linear extrapolations were used to complete the historical time-series.

8.2 Historical Emissions

Nevada's agriculture sector is a minor source of GHG emissions. Total sector emissions were estimated at approximately 1.4 $MMtCO_2eq$ in 2010, about 3% of total GHG emissions for Nevada. Historical data showed a limited variability, with GHG emissions peaking at about 1.5 $MMtCO_2eq$ in 2001 and slowly declining thereafter. Overall, emissions from livestock digestion accounted for more than 50% of total sector emissions; cultivated land practices (including synthetic and organic fertilization, tilling practices and production of nitrogen-fixing crops) accounted for about 35-40%; manure management accounted for about 10% of total emissions in the agriculture sector (Figure 8.1). While residual burning is practiced in Nevada, emissions from this activity were negligible.

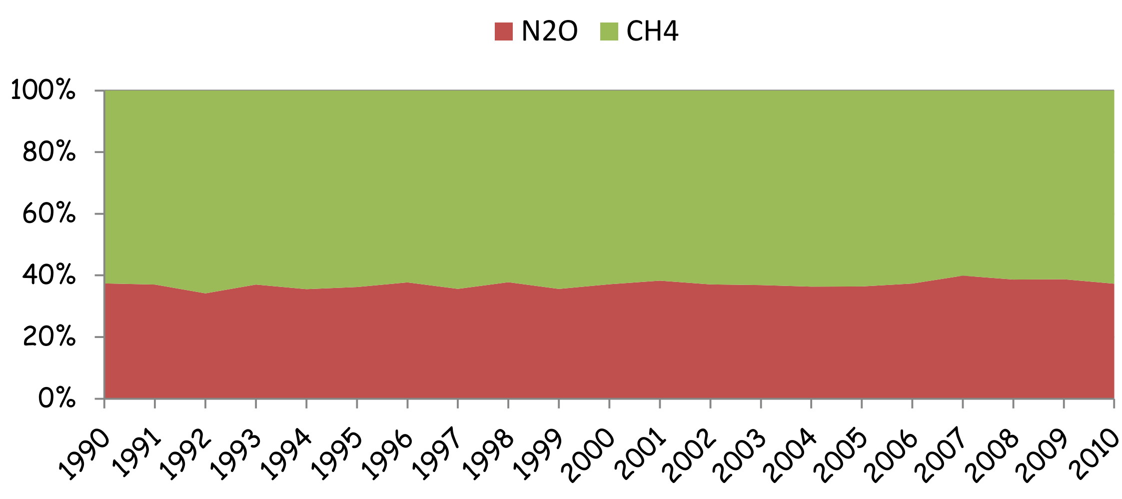
[27] http://quickstats.nass.usda.gov/

Figure 8.1: Main GHG emissions from the agriculture sector. CH_4 is released during ruminant digestion (enteric fermentation); manure management describes N_2O and CH_4 emissions due to animal waste treatment, with the exclusion of emissions from manure used as soil fertilizer; 'Cultivated Land' is a category that describes N_2O and CH_4 emissions from soil caused by a wide range of agricultural practices, such as synthetic and animal waste fertilization, farming practices, and production of nitrogen-fixing crops. Emissions from agricultural residual burning are present in Nevada but their magnitude is very small and therefore not represented in this graph.



The relative contribution of N_2O and CH_4 to total emissions in the agriculture sector was constant for the entire 1990-2010 period, approximately 40% and 60%, respectively (Figure 8.2).

Figure 8.2: Relative contribution of each GHG type to total emissions in the agriculture sector.



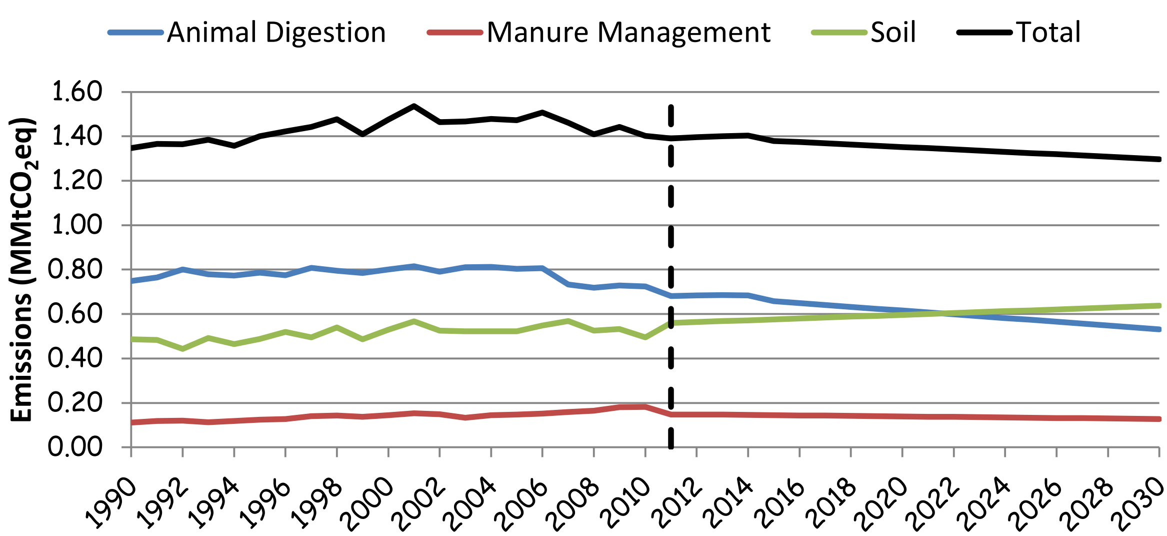
8.3 Projected Emissions

Emissions from both animal digestion (enteric fermentation) and manure management are dependent on livestock population. There are no local and specific data on future livestock population in Nevada. The agricultural sector in the state is projected to have no employment growth in the period 2010-

2020[28]. Similarly, projections for US livestock show an annual decline in livestock population between 0.7% and 2.5% for the period 2010-2030, depending on the type of animal. As recommended by SIT 2012, livestock projections were used to estimate emission in manure management and animal digestion for the period 2011-2030. Emissions from soil-related practices are mainly driven by fertilizer use. It is reasonable to assume that population growth, which is a good indicator for demand in agricultural products, can be used as an indicator for fertilizer demand as well. Projected emissions for the soil-related practices were obtained by using the population growth rates for 2010-2030 (Nevada State Demographer) and by linearly extrapolating emission trends observed in the period 1990-2010 (as recommended by SIT 2012 when more detailed and/or local analyses are not available). Results from both methods showed very marginal differences.

Total emissions for the agriculture sector between the 2011-2030 period are not expected to substantially differ from historical trends. Emissions in 2030 are projected to be 1.3 MMtCO_2eq, with a marginal decline from 1.4 MMTCO_2eq in 2010 (Figure 8.3). Overall, total emissions from the agriculture sector are projected to contribute to statewide GHG emissions by only 2.5%, in 2030.

Figure 8.3: Historical and projected emissions for the agriculture sector. CH_4 is released during ruminant digestion (enteric fermentation); 'manure management' describes N_2O and CH_4 emissions due to animal waste treatment, with the exclusion of emission from manure used as soil fertilizer; 'soil' is a category that describes N_2O and CH_4 emissions from soil caused by a wide range of agriculture practices, such as synthetic and animal waste fertilization, farming practices, and production of nitrogen-fixing crops. While emissions from agricultural residual burning are present in Nevada, their current and future magnitude is very small and could not be represented in this graph. The vertical dashed line marks the end of historical emissions and the beginning of projections.



[28] Nevada Department of Employment Training and Rehabilitation – Research & Analysis Bureau, http://www.nevadaworkforce.com

9 Waste management sector emissions

9.1 Overview

Waste management GHG emissions occur from two source categories, namely, solid waste and wastewater management. In landfills, CH_4 and CO_2 are produced from anaerobic decomposition. However, neither the CO_2 emitted directly as biogas nor the CO_2 emitted from combusting CH_4 at flares is counted as an anthropogenic GHG emission. This is because CO_2 is primarily released by decomposition of organic materials derived from biomass sources (e.g., crops, forests), which initially sequestered an equivalent amount of CO_2 from the atmosphere. Similarly, CO_2 and N_2O emissions from waste combustion of materials such as paper, food scraps, and plastic, are not counted as GHG because they return CO_2 that plants previously absorbed through photosynthesis from the atmosphere. Last but not least, much of the carbon in landfills is stored indefinitely and removed from the pool of carbon available to cycle to the atmosphere. Emissions accounted as GHG in this report are from non-biogenic sources (e.g., CO_2 from plastic and rubber made from petroleum), and N_2O emitted during waste combustion because of high temperatures used in the process.

Disposal and treatment of industrial and municipal wastewater often result in N_2O and CH_4 emissions. The amount of methane produced by wastewater depends on the organic content (or loading) of the water (expressed in terms of biochemical oxygen demand, BOD); under the same conditions, wastewater with higher BOD will emit more CH_4. N_2O emissions depend on the nitrogen content of the wastewater, which is dependent on the consumption of dietary proteins in the human population.

It is estimated that landfill waste continues to emit CH_4 for several decades after its emplacement. Emission rates follow an exponential decay curve, quickly diminishing after a few years, but still being larger than zero for the next three to six decades, depending on the climate of the region (decay takes longer in arid climates). Therefore, in order to calculate annual emissions from landfills it is not only important to estimate the waste in place (WIP, i.e. the amount of waste since the beginning of landfill activity), but also the relative amount of waste that was emplaced annually during the landfill lifetime (see Figure 11.11 for an example of the approach used in this report).

Data from the Nevada Statewide GHG Emission Inventory and Projections - 1990-2020 (2008), State of Nevada Solid Waste Management Plan (2007), and EPA Landfill Methane Outreach Program (LMOP 2012[29]), were integrated to obtain the most up-to-date estimates of WIP in each of the largest municipal waste landfills in Nevada. WIP for each landfill was redistributed across the years of activity based on Nevada's population statistics. Finally, CH_4 emissions from landfills were reduced by the presence of gas recovery systems such as flaring, landfill gas collection systems (LFG), and landfill gas-to-energy (LFGTE). A detailed description on the data and methodologies adopted to estimate emissions from solid waste management can be found in Section 11.4.

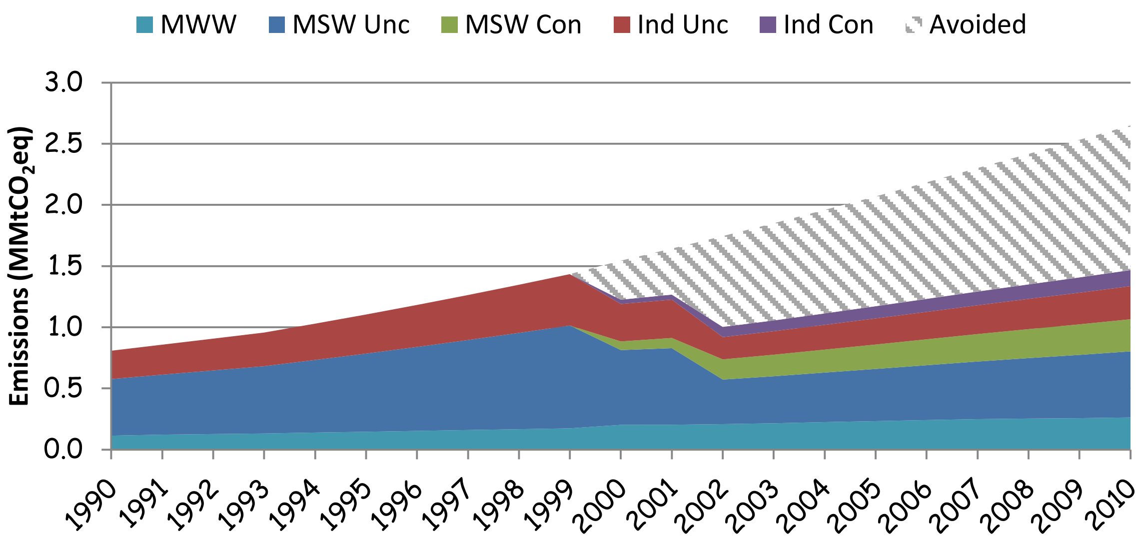
[29] http://www.epa.gov/lmop/publications-tools/index.html

The estimation of GHG emissions from municipal and industrial wastewater treatment were calculated using the method recommended by SIT 2012, which is based on state population.

9.2 Historical Emissions

GHG emissions from solid and wastewater management were marginal in Nevada, accounting for approximately 2-3% of total GHG emissions in the state. CH_4 emissions accounted for approximately 94% of total emissions. Emissions from the waste management sector increased from approximately 0.8 $MMtCO_2eq$ in 1990 to 1.4 $MMtCO_2eq$ in 2010 (Figure 9.1), with solid waste management representing more than 80% of these emissions. Noticeably, the installation of gas-reduction systems in the Apex and Sunrise landfills largely contributed to the reduction of GHG emissions; the estimated avoided emissions of CH_4 were almost equivalent to the actual total emissions in 2010 (Figure 9.1).

Figure 9.1: GHG emissions from solid and water waste management. Emissions from solid waste management were disaggregated in two main groups: emissions from landfills with no gas-recovery systems (uncontrolled, 'Unc') and emission from landfills with gas-recovery systems (controlled, 'Con'). It is important to notice that all of the controlled landfills had the gas-recovery systems installed well after their activities started, so they contributed to the uncontrolled group emissions for part of their activity history. Emissions were further disaggregated into municipal (MSW) and Industrial (Ind). Emissions from municipal wastewater management (MWW) are shown, but emissions from industrial wastewater management are negligible in Nevada. Also, this graphic shows GHG emissions that were avoided, i.e. gas that was not emitted into the atmosphere, because of the adoption of gas-recovery systems ('Avoided').

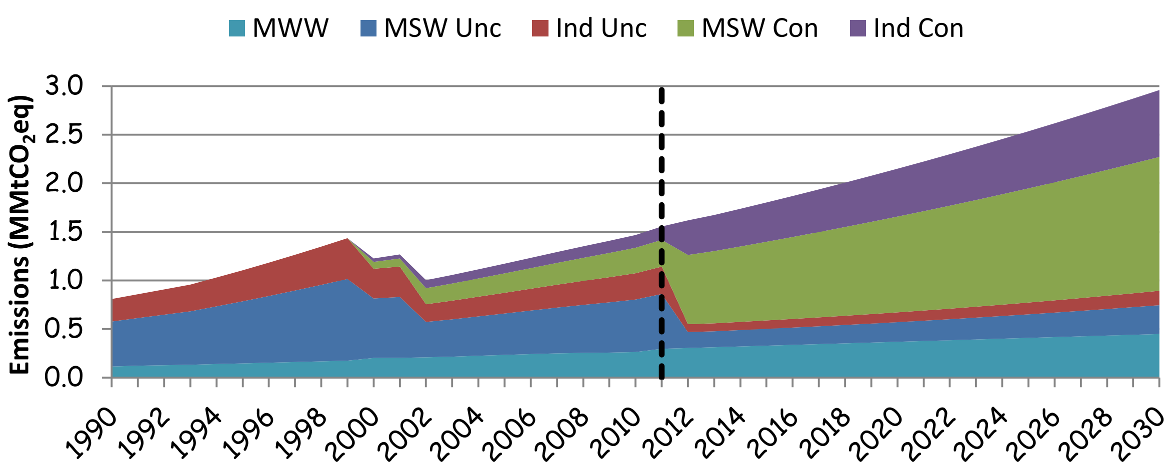


9.3 Projected Emissions

Waste production and its placement in landfills are dependent on population growth. GHG emissions from the solid waste management sector were estimated based on the projected Nevada population growth (Nevada State Demographer), the information about current and future landfill management obtained from LMOP, and on the recommended (SIT 2012) model for emissions from landfills. A detailed description of the adopted methodology can be found in Section 11.4.2. Emissions from wastewater management were projected by extrapolating the linear trends observed for the period 1990-2010, as recommended by SIT 2012.

GHG emissions are projected to reach approximately 3.0 $MMtCO_2eq$ by 2030, about 5.6% of total statewide emissions. Noticeably, emissions from controlled landfills will account for about 70% in 2030, more than doubling their contribution of 30% in 2010. This increase reflects the use and the introduction of gas-recovering technologies in the top three largest landfills in Nevada: Sunrise LF, from 2002; Apex LF, from 2000; Lockwood LF, from 2012 (see Section 11.4 from more details). Emissions from wastewater management are predicted to account for less than 20% of total waste management emissions without any significant change in their contribution for the period 1990-2030.

Figure 9.2: Historical and projected emissions for the waste management sector. Emissions from solid waste management are shown separately for landfills that have gas-recovery systems ('MSW Con' and 'Ind Con', for municipal solid waste, and industrial controlled, respectively) and for landfills without such systems ('MSW Unc' and 'Ind Unc', for municipal solid waste and industrial uncontrolled, respectively). Emissions from municipal wastewater management (MWW) are shown, but emissions from industrial wastewater management are negligible in Nevada. The vertical black dashed line marks the end of historical data and the beginning of projections.



10 Land Use, Land Use Change, and Forestry Sector Emissions

10.1 Overview

This section includes GHG emissions from land -use and -change activities and from the forestry sector. Temperate forests in the Northern hemisphere are in general CO_2 sinks, as their net carbon flux balance (i.e., carbon emissions minus carbon sequestration) is negative, hence actively contributing to offset anthropogenic GHG emissions. The strength of these sinks, per unit of area, widely depends on many factors, such as forest species composition, climate variability, and the occurrence of perturbations like fires and diseases. Other natural ecosystem types (e.g., grasslands, shrublands, wetlands, etc…) contribute as well to the overall carbon flux balance, but the current scientific consensus is that they are, on average, close to neutrality. The main approach adopted to estimate carbon (in the form of CO_2) sequestration in forests relies on estimating the magnitude of distinct carbon pools (i.e., the total amount of carbon found in each pool, or *stock*, such as aboveground biomass, soil, roots, etc…) in the forest ecosystems and their change through time (i.e. the net change of carbon in all pools of a forest, which is equated to carbon flux between the forest ecosystem and the atmosphere, or other compartments of the biosphere). The USDA-Forest Service collects, manages, analyses and makes available such data through the Forest Inventory and Analysis program (FIA[30]). In this respect, a positive change in overall carbon stocks per unit of area of a forest indicates net carbon uptake (i.e., CO_2) from the atmosphere. However, carbon stocks can change as a result of land use change (i.e., increase or decrease of forested areas), logging, and fire events, which both decrease the amount of forest carbon stocks. Land use and land use change only marginally contribute to GHG emissions in Nevada (Nevada Statewide Greenhouse Gas Emissions Inventory and Projections, 1990-2020). Nevertheless, wildfires and prescribed fires can significantly contribute to the annual carbon balance of the forests and other natural ecosystems. It is important to note that the carbon released by fires in forests and other natural ecosystems is not accounted in the GHG inventory. This is because the loss of carbon from forests is already accounted for by either the carbon-pool inventory approach (in forests), or balances an equivalent amount of carbon previously sequestered through photosynthesis (in other natural ecosystems). CH_4 and N_2O are also released during fires and they need to be included in the GHG inventory as emissions.

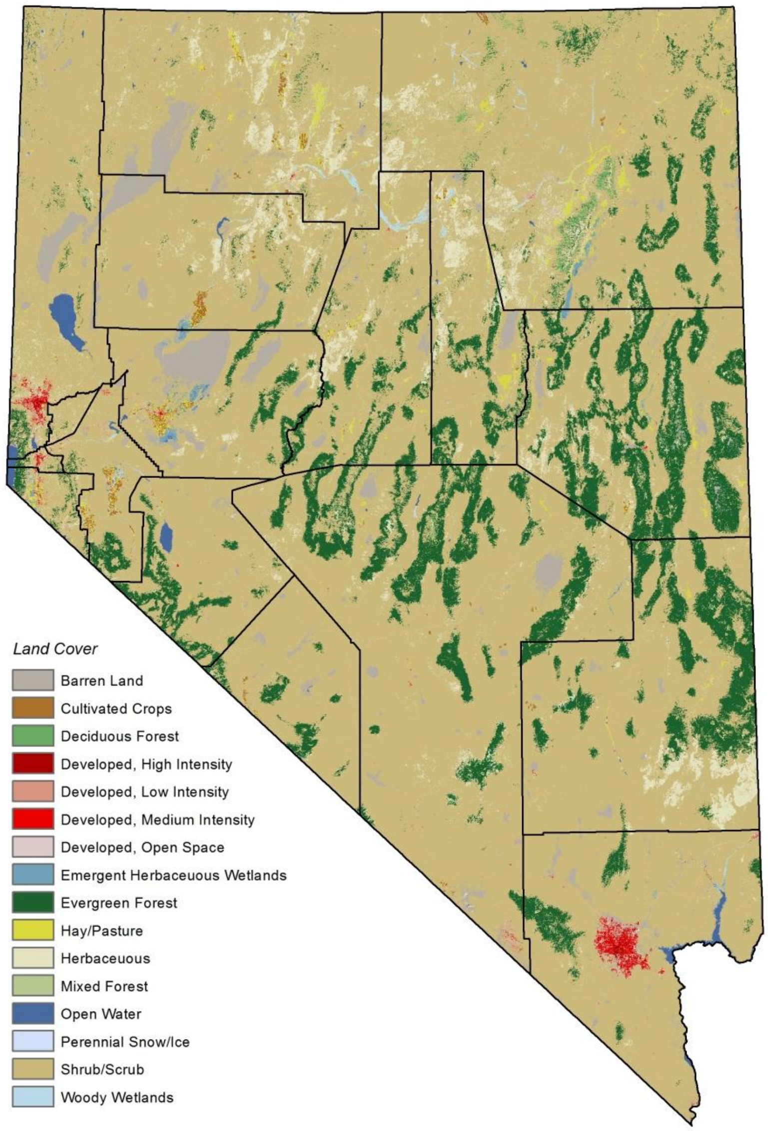
SIT 2012 provides methodologies, and emission factors to estimate net GHG emissions from the forestry sector, and historical data on the areas affected by fires in Nevada were obtained from the National Interagency Fire Center (NIFC[31]). A detailed description of the assumption and data used in this section is provided in Section 11.5.

[30] http://www.fia.fs.fed.us/
[31] http://www.nifc.gov/

10.2 Historical Emissions

Forests in Nevada covered approximately 3,100,000 hectares in 2006[32], equivalent to 11% of Nevada's land (Figure 10.1).

Figure 10.1: Land cover in Nevada[32]

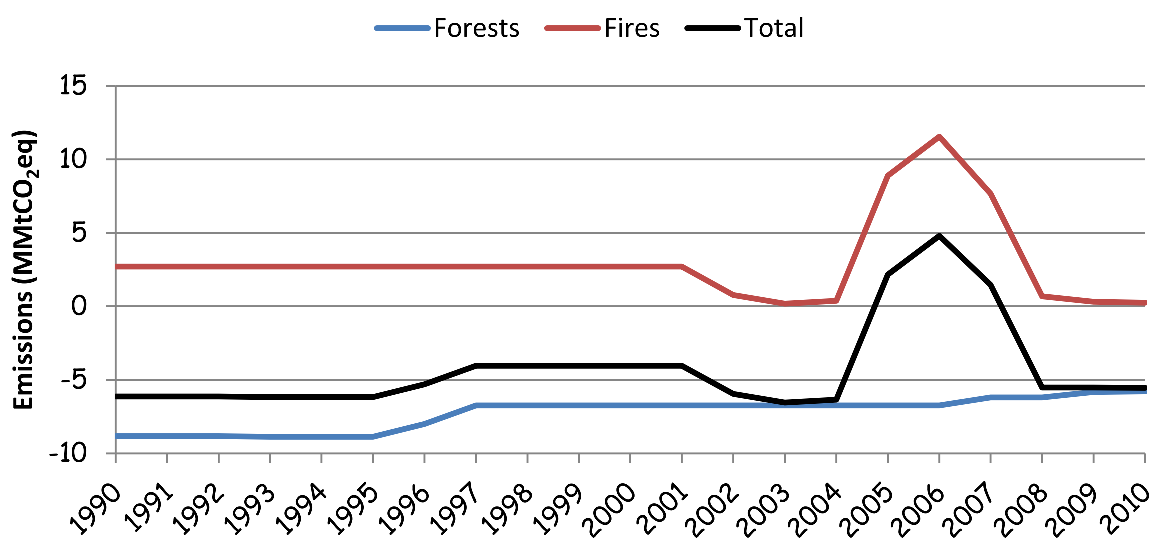


Fire emissions and CO_2 uptake by forests are the two main factors contributing to the total emissions of this sector. Forest uptake was relatively constant across the period 1990-2010, ranging between 6 and 9 $MMtCO_2eq$ sequestered every year from the atmosphere (Figure 10.2). This corresponded to about 13% of total GHG emissions in Nevada in 2010. Fire emissions were extremely variable, averaging 3.0 $MMtCO_2eq$, but peaking at about 10 $MMtCO_2eq$ during 2006, when more than 1,000,000 acres were

[32] Multi-Resolution Land Characteristics Consortium, MRLC, http://www.mrlc.gov/nlcd2006.php

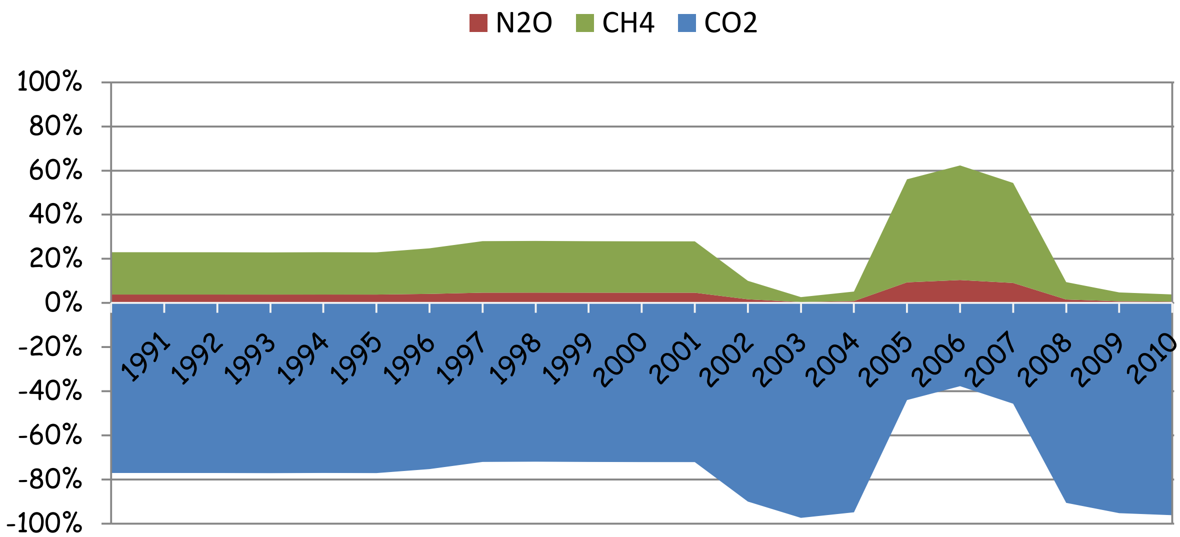
burned mostly by wildfires. Between 2005 and 2007, fire emissions largely offset carbon sequestration by forests, resulting in additional GHG emissions for Nevada.

Figure 10.2: Emissions from fires and CO_2 sequestration by forest (expressed as negative numbers). Positive total values indicate that emissions from fires offset CO_2 uptake by forests. Negative total values indicate that CO_2 uptake by forests was larger than total emissions from fires.



When presenting the relative contribution of each GHG to the land use, land-use change, and forestry sector, it is more appropriate to use the term 'exchange', rather than 'emissions'. This is because a large amount of atmospheric CO_2 is sequestered by forests through photosynthesis (partially counterbalancing GHG emissions), and a significant amount of CH_4 and N_2O is emitted during fire events. The relative contribution of each GHG is therefore expressed in relation to the total GHG exchanged, rather than exclusively emitted GHG. Because the scope of this report is to quantify GHG emissions to the atmosphere (reported as positive numbers), the amount, or fraction, of CO_2 that is taken up from the atmosphere is reported as negative numbers. In Nevada, CO_2 **uptake** by forests was approximately 80% of total GHG exchanged, while N_2O and CH_4 **emissions** were around 20% of total GHG exchange Figure 10.3). Exceptions are those years between 2005 and 2007 when because of large fires, the relative contribution of N_2O and CH_4 emissions increased up to 60% of total GHG exchange for the sector.

Figure 10.3: Relative contribution of each GHG type to total GHG exchange in the land use, land-use change, and forestry sector. The term 'exchange' is used instead of 'emissions' because forests can counterbalance GHG emissions by sequestering CO_2. The contribution of forests to total CO_2 emissions is given by the net balance of respiration, which releases CO_2 to the atmosphere, and photosynthesis, which sequesters CO_2 from the atmosphere. Nevada's forests sequestered more CO_2 than what they released, and therefore their contribution is shown as negative numbers. For instance, in the year 1995, CO_2 uptake was approximately 80% of total GHG exchange, and N_2O and CH_4 emissions were 20% of total GHG exchange.



10.3 Projected Emissions

The productivity (and hence CO_2 uptake from the atmosphere) of forests is well expected to decrease on a time-scale of a hundred or more years because of their natural life cycle. However, much less is known about the effects of climate variability (time scale of 10-20 years) on forest productivity and ability to offset anthropogenic GHG emissions. Also, unpredictable natural disturbances (fires and diseases) can strongly alter forest dynamics and productivity. For these reasons, no reliable or recommended method is provided by SIT 2012 to estimate 2010-2030 emissions. Due to this limitation, projections for the forestry, including fire emissions, sector were estimated by extrapolating the average 1990-2010 emissions (-4.5 $MMtCO_2eq$) for the period 2011-2030. Total statewide emission projections for 2030 are estimated at approximately 53 $MMtCO_2eq$. The forestry sector is projected to offset about 9% of these emissions in 2030.

11 Appendixes

11.1 Electrical power generation

11.1.1 Alternative estimate of emission from electrical power generation

Nevada is part of the interconnected region managed by the Western Electricity Coordinating Council (WECC). Due to this interconnection, electricity generated in Nevada can be exported to serve needs in other states and, conversely, electricity used in Nevada can be generated and imported from plants outside the state. Since almost all states are part of regional trading grids, many states that have developed GHG inventories have grappled with the problem of how to account for flows of electricity across the state borders. The approach presented here, represents a compromise between the coarse GHG emission assessment provided by the production- and consumption-based methods, and a detailed analysis of all the electricity flows across the state. The ***total net electricity*** is defined as the amount of electricity, either generated or imported, that is used to support industrial, commercial, and residential activities within the state of Nevada. In other terms, the total net electricity is

Total net electricity = *Electricity generated within the state* - *Electricity exported out of state* + *Electricity imported from other states*

The main assumption is that total net electricity is equal to the reported statewide end-user electricity consumption (i.e., from retail sales). This assumption has the advantage of reducing the number of datasets required to estimate GHG emissions (for instance, no data on electricity export are required). But equally important, this assumption provides an independent estimate of the electricity consumed by within-the-state activities (either generated in Nevada or imported). If total net electricity can be equated to the end-user consumption of electricity, then

End-user consumption of electricity = *Electricity generated and used within the state* + *Electricity imported from other states*

US-EIA-SEDS provides datasets about consumption and import of electricity at the state level. Therefore, it is now possible to estimate the amount of *electricity that is generated and used within the state* by re-arranging the terms of the above equation

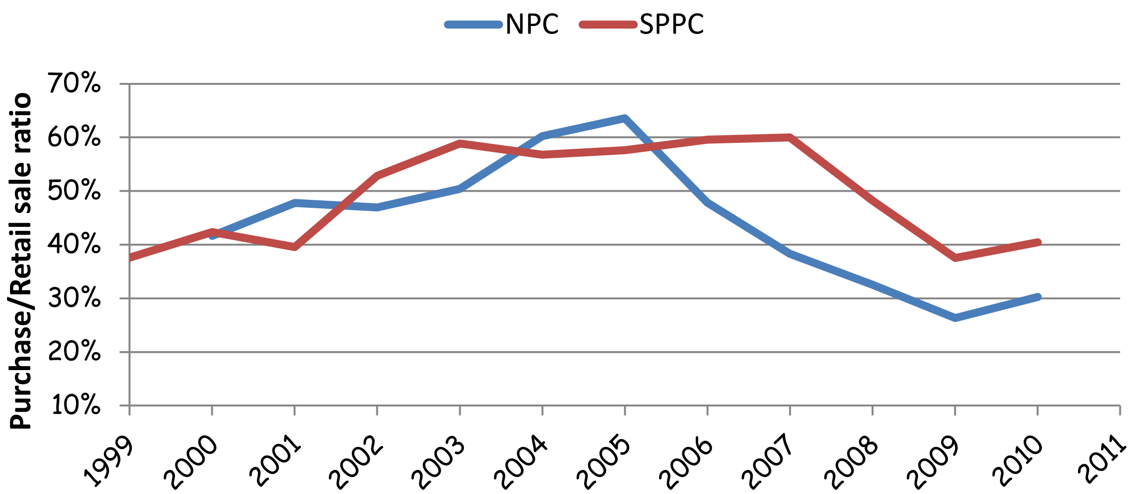
Electricity generated and used within the state = *End-user consumption of electricity* - *Electricity imported from other states*

Once the amount of *electricity generated and used within the state* is known, the *Total net electricity* can be calculated as

Total net electricity	=	*Electricity generated and used within the state*	+	*Electricity imported from other states*

Figure 11.1 shows the percentage of electricity retail sales that are provided through purchase by NPC and SPPC. Data were collected from the DOE- EIA[33] and where available from 1999.

Figure 11.1: Percentage of electricity retail sales that are fulfilled by energy purchase for Nevada Power Company (NPC) and Sierra Pacific Power Company (SPPC).



In order to convert electricity generation and import into GHG emissions, the correct emission rates need to be applied. The US-EPA eGRID[34] provides nationwide current and historical emission rates at electric generating company, eGRID sub-region, and NERC (North America Electric Reliability Corporation) aggregates. The emission rates from Nevada Power Company (NPC) and Sierra Pacific Power Company (SPPC) were used, as they represent the large majority of electricity production and distribution in Nevada, to estimate the average historical emission rates for Nevada. In particular, these rates were calculated as the average of NPC and SPPC emission rates weighted by their respective net generation. The US-EPA eGRID sub-region emission rates were used for the electricity imported. The WECC-Northwest sub-region (NWPP in Figure 11.2) was used for the electricity imported by SPCC and the WECC-Southwest sub-region (AZNM in Figure 11.2) for the electricity imported by NPC. Because emission rates from EPA eGRID were not continuous for the 1990-2010 period, linear interpolation was used to derive the missing years (Figure 11.3).

[33] US-EIA Form 861 http://www.eia.gov/cneaf/electricity/page/data.html
[34] http://www.epa.gov/cleanenergy/energy-resources/egrid/

Figure 11.2: EPA-eGRID sub-regions. eGRID sub-regions are identified and defined by EPA, using the larger NERC (North America Electric Reliability Corporation) regions and power control areas (PCA) as a guide. The map below was reproduced from eGRID 2007 dataset.

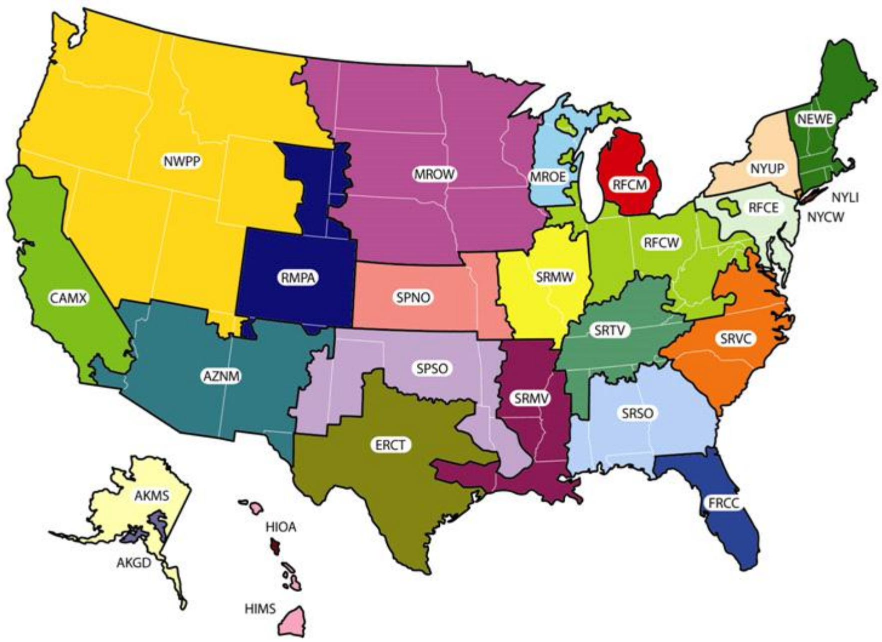
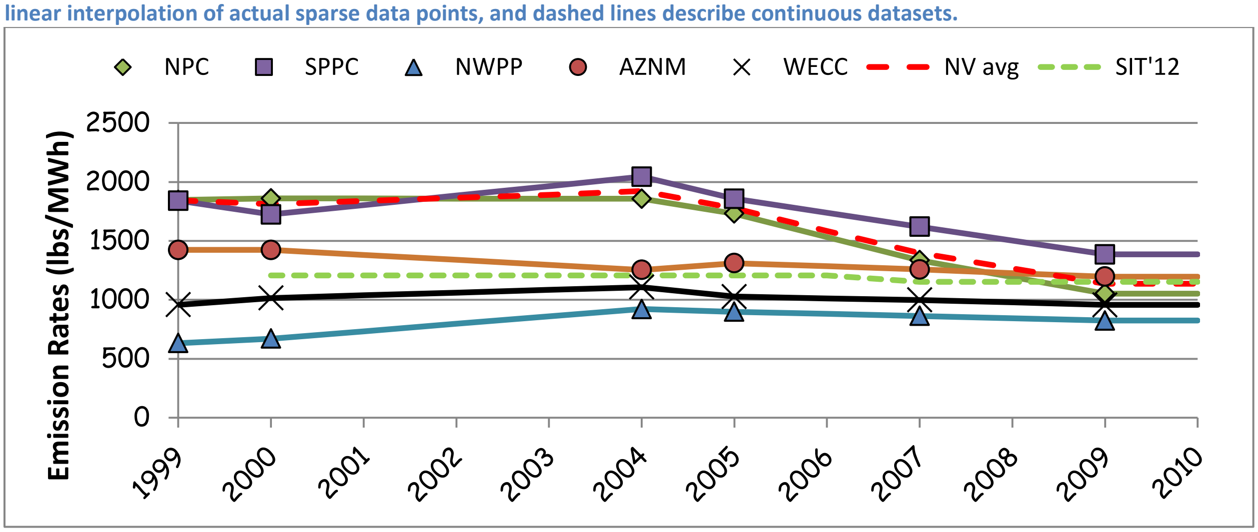


Figure 11.3: Emission rates (lbs of CO_2 per MWh generated) for different aggregation level: Nevada Power Company (NPC); Sierra Pacific Power Company (SPCC); EPA eGRID sub-region WECC-Northwest (NWPP); EPA GRID sub-region WECC-Southwest (AZNM); WECC region (WECC); estimated average for Nevada power generation (NV avg); emission rates used in SIT 2012 (SIT'12). Symbols describe actual, but sparse, data points, solid lines describe continuous datasets obtained by linear interpolation of actual sparse data points, and dashed lines describe continuous datasets.



Using the above described emissions factors and electricity generation datasets it was possible to estimate GHG emissions for Nevada as discussed in the first part of this section. Results are shown in section 3.2.3.

11.1.2 Scenarios from 2008 Nevada GHG Emission Inventory and Projections

In the 2008 Nevada Statewide GHG Emissions Inventory and Projections[1], seven scenarios were considered in estimating projected emissions for the period 2008-2020. These seven scenarios were different combinations of generation plant retirements and additions. The following table duplicates Table 2.3 of the 2008 report.

Table 11.1: Scenarios for electrical generation emissions considered in the 2008 Nevada Statewide GHG Emissions Inventory and Projections. This is a duplicate of Table 2.3 from 2008 Report. None of the planned coal-based power plants was built and the Reid Gardner units 1-3 were not retired; Mohave plant was permanently closed.

Scenario	Descriptor	Explanation
1	IRP Reference Case	This scenario is based on NV Energy's proposed generation plant additions and retirements included in table 2.2, including Phase I of the Ely Energy Center (EEC) and the retirement of the coal-fired Reid Gardner units 1-3. Construction of the other proposed coal fired power plants and restart of the Mohave plant are not included in this scenario. The scenario does not consider the construction of Phase II of the Ely Energy Center as the date of construction of this facility is unknown.
2	White Pine Coal	This scenario is the same as scenario 1 except the EEC is replaced by the White Pine Energy Station and Reid Gardner units 1-3 are not retired.
3	Toquop Coal	This scenario is the same as scenario 1 except that the EEC is replaced by the Toquop Energy Project and Reid Gardner units 1-3 are not retired.
4	All New Coal	This scenario includes the projected emissions under scenario 1 as well as the emissions generated by the White Pine and Toquop coal plants.
5	No New Coal	This scenario includes the projected emissions of scenario 1 without the construction of any of the three proposed coal plants and non-retirement of Reid Gardner units 1-3.
6	Mohave Restart as Natural Gas Only	This scenario projects the same emissions as scenario 1 except that no new coal fired generation is added, Reid Gardner units 1-3 are not retired, and the Mohave plant is restarted and operated only on natural gas starting in the time period of 2011-2015.
7	Mohave and 1500 MW of New Coal	This scenario is the same as scenario 6 with the addition of one new coal plant of 1500 MW capacity in 2015.

11.2 Transportation sector: additional graphs and calculations

Disaggregated vehicle miles travelled were used to estimate CH_4 and N_2O emissions from the transportation sector and to perform further analyses and project emissions for the 2010-2030 period. Total annual VMT was obtained from the Nevada Department of Transportation. However, in the absence of detailed data, disaggregation into vehicle and fuel types were performed using national averages[35].

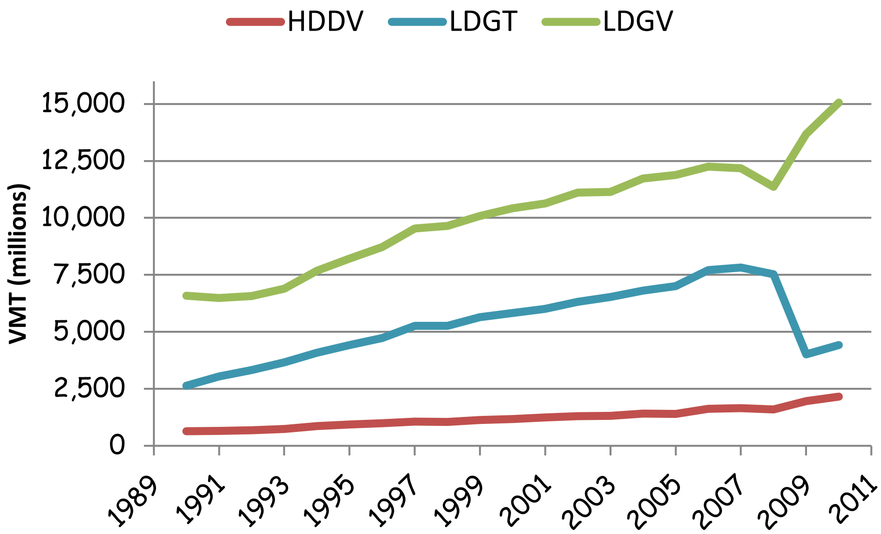
Table 11.2: Description of the acronyms used to define vehicle type and fuel use.

Acronym	Description
HDDV	Heavy duty diesel vehicle
LDDV	Light duty diesel vehicle
LDDT	Light duty diesel truck
HDGV	Heavy duty gasoline vehicle
LDGV	Light duty gasoline vehicle
LDGT	Light duty gasoline truck
MC	Motorcycles

Figure 11.4 shows VMT disaggregated by vehicle type and fuels use. The effects of the economic downturn in 2007 are apparent for many of these categories, but in particular for LDGV, LDDT, and LDGT. However, while VMT for small gasoline vehicles already recovered to even higher levels and growth rates than the pre-recession period, VMT for both diesel and gasoline light-duty trucks still shows much lower levels and growth rates than 2007.

[35] The Federal Highway Administration (FHWA), in FHWA's Highway Statistics report (Table VM-2), available online at: http://www.fhwa.dot.gov/policy/ohpi/hss/index.cfm

Figure 11.4: Annual vehicle mile traveled (VMT) disaggregated by vehicle and fuel type[35]. Total VMT are from the Nevada Department of Transportation, however, they were disaggregated based on national statistics. Data were divided into separate graphs to enhance visibility. See Table 11.2 for acronym description.



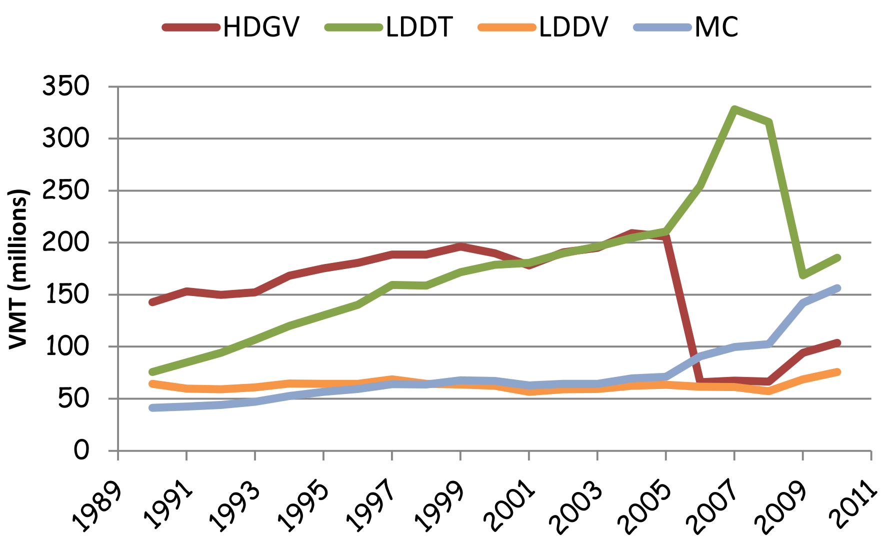
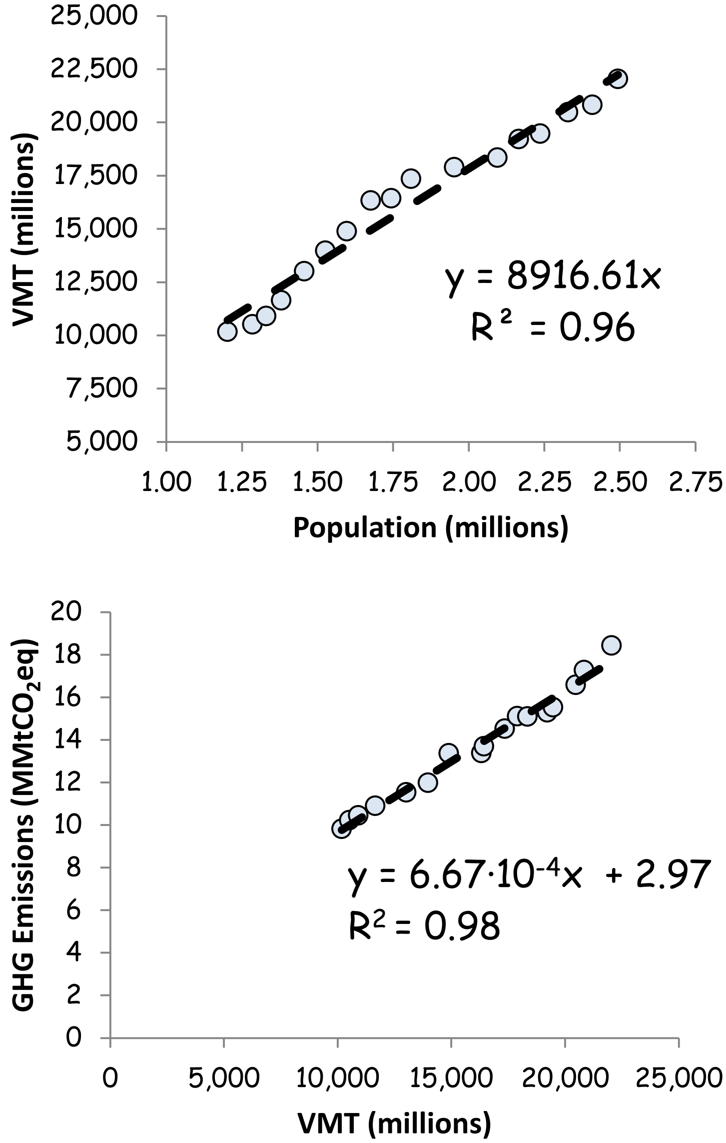


Figure 11.5 shows the existing relationship between VMT and population in Nevada, and GHG emissions and VMT for the period 1990-2006 (i.e., by excluding the effects of the economic-downturn). These relationships were used to project emissions for the transportation sector and for the period 2010-2030 (see Section 5.3).

Figure 11.5: Relationship between annual total vehicle miles travelled and population in Nevada (top) and between GHG emissions and VMT (bottom). Data are relative to the period from 1990 to 2006, i.e. pre-2007-recession.



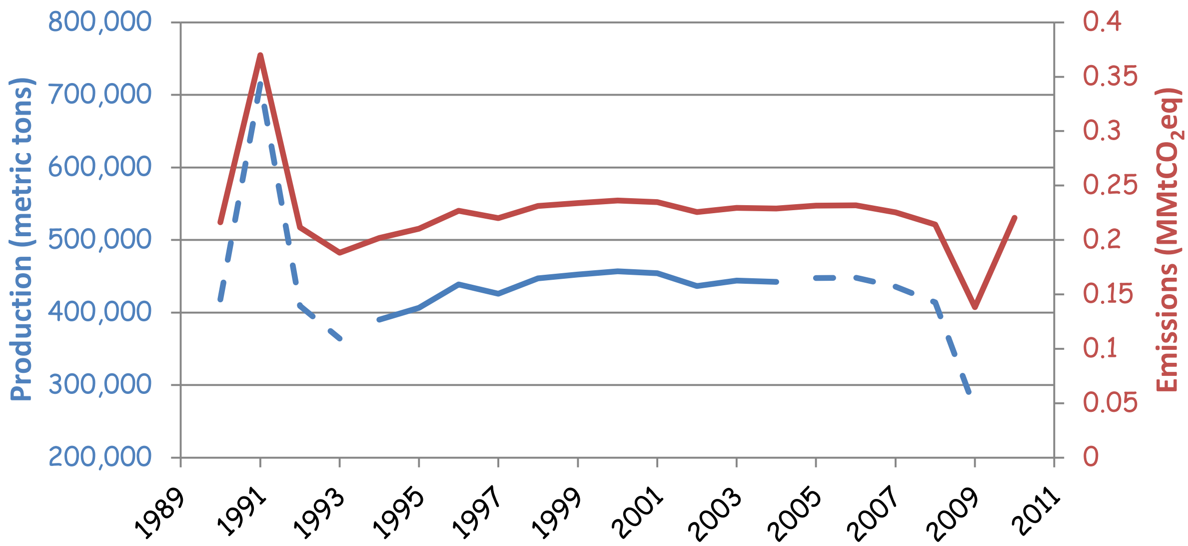
11.3 Industrial processes emissions

11.3.1 Historical Emissions

11.3.1.1 Cement Manufacture

Emissions factors for clinker and cement kiln dust production were obtained from SIT 2012. State production for the years from 1994 to 2004 was obtained from the Nevada GHG Emission Report (2008). Production data are also available from the USGS Minerals Yearbook[36] from 1990 to 2009. However, these data are provided as total aggregated production for Idaho, Montana, Utah and Nevada. Actual Nevada production from 1994 to 2004 was used to partition aggregated USGS data for the years 1990-1993 and 2005-2009. The US-EPA 2010 GHG Report[37] was used to obtain 2010 emissions for cement manufacturing in Nevada (Figure 11.6).

Figure 11.6: Actual (solid line) and estimated (dashed line) clinker and kiln dust production, and GHG estimated emissions for Nevada. Production is not reported for 2010 as emissions were directly obtained from 2010 EPA GHG inventory.



11.3.1.2 Lime Manufacture

Emissions from high-calcium and dolomitic lime manufacturing were calculated using specific emission factors obtained from SIT 2012. High-calcium and dolomitic lime production for the years 1994-2005 was obtained from the Nevada GHG Emission Report (2008). Production data are also available from the USGS Minerals Yearbook from 1991 to 2009[36]. However, these data are aggregated as total lime production (i.e., high-calcium plus dolomitic lime) for the states of Arizona, Colorado, Idaho, Montana, New Mexico, Utah, Wyoming, and Nevada. Actual Nevada production from 1994 to 2005 was used to partition aggregated USGS data for the years 1991-1993 and 2006-2009. Production in 1990 was assumed to be similar to that in 1991. The US-EPA 2010 GHG Report[37] was used to obtain 2010 emissions for lime manufacturing in Nevada (Figure 11.7).

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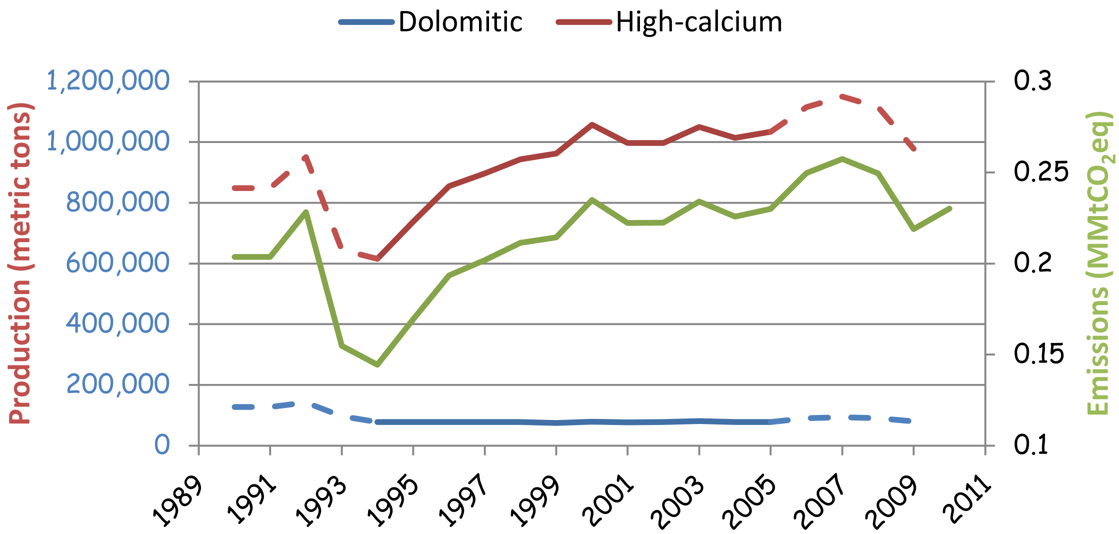
[36] http://minerals.usgs.gov/minerals/pubs/commodity/myb/
[37] http://ghgdata.epa.gov/ghgp/main.do

Figure 11.7: Actual (solid line) and estimated (dashed line) dolomitic (blue line) and high-calcium (red line) lime production, and GHG estimated emissions (green line) for Nevada. Production is not reported for 2010, as emissions were directly obtained from US-EPA 2010 GHG inventory[37].



11.3.1.3 Limestone and dolomite use

Emission factors and use data for Nevada were obtained from SIT 2012 from 1990 to 2009. For 2010, emission factors from 2009 were used. Nevada limestone and dolomite use for 2010 was estimated by partitioning the 2010 nationwide use according to the 2009 Nevada vs. US ratio.

11.3.1.4 Soda ash consumption

State consumption of soda ash was estimated by partitioning the total U.S. consumption using the fraction of Nevada population vs. U.S. population. Total U.S. consumption of soda ash was obtained from the USGS Minerals Yearbook for 1990-2009[37]. Consumption in 2010 was assumed to be equal to that in 2009. Total U.S. population and Nevada population for 1990-2010 was obtained from the U.S. Census and Nevada State Demographer, respectively. Emission factors were obtained from SIT 2012.

11.3.1.5 Ammonia production and urea consumption

Emission factors and production and consumption data were obtained from SIT 2012.

11.3.1.6 Nitric acid production

Emission factors were obtained from SIT 2012. Production data from 1994 to 2005 were obtained from the Nevada GHG Emission Report (2008). No data are available from 2006 to 2009, and no indication of nitric acid production is reported in the EPA GHG Emission Inventory (2010).

11.3.1.7 Ozone depleting substance substitutes (ODSS)

ODSS emissions for Nevada from 1990 to 2010 were estimated by partitioning the U.S. total emissions using the fraction of Nevada over national population (from U.S. Census and Nevada State Demographer data).

11.3.1.8 Semiconductor manufacturing
National emissions are apportioned to Nevada using the ratio between state and national shipments (available only for 1997 and 2002, interpolated/extrapolated otherwise).

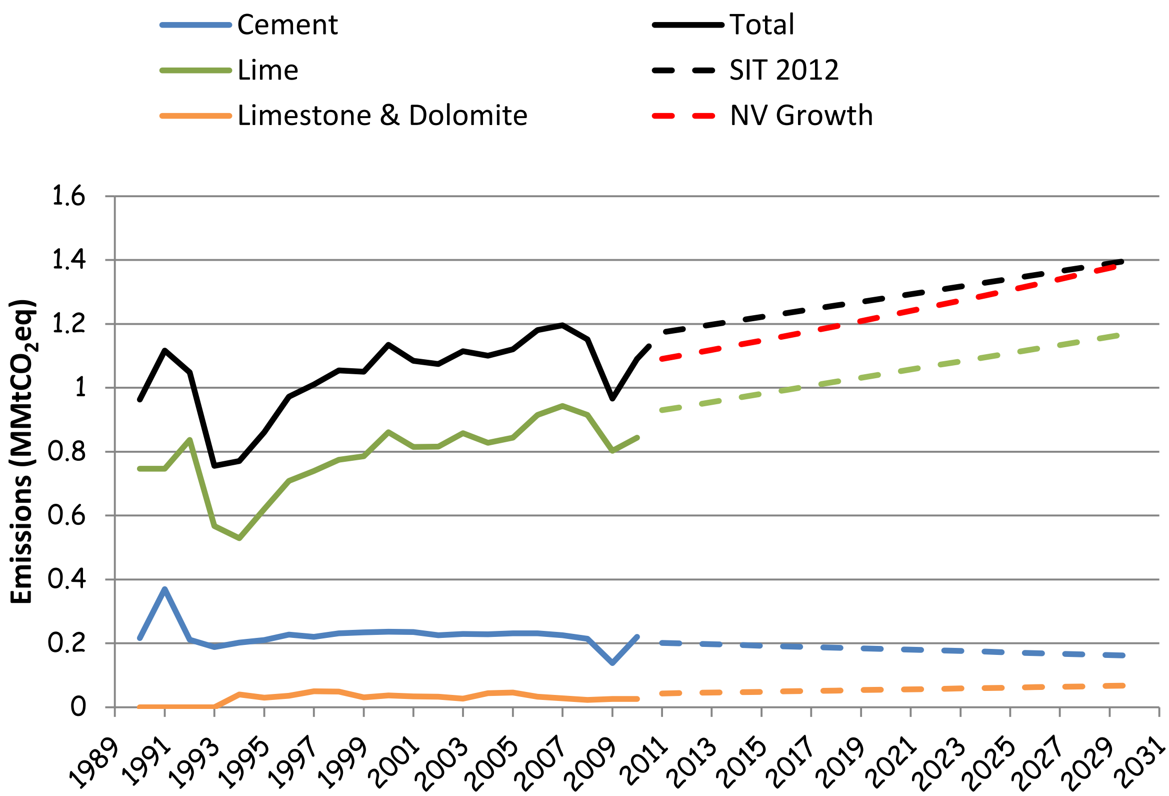
11.3.1.9 Electric power transmission and distribution systems
The largest use for SF_6 is as an electrical insulator in electricity transmission and distribution equipment. SF_6 emissions for Nevada were calculated by partitioning the national SF_6 consumption by the ratio between Nevada and U.S. sales of electricity. Both state and nationwide sales for the period 1990-2010 were obtained from the US-EIA. National SF_6 consumption and emission factors were obtained from SIT 2012 and EPA GHG Emission Inventory (2010)[37].

11.3.2 Projection Emissions

11.3.2.1 Cement and lime manufacture and limestone and dolomite use
Many macroeconomic factors can influence the projections for these industrial activities. SIT 2012 recommends that projections for 2011-2030 should be based on the 1990-2010 trends, especially when local and/or more detailed analyses are not available. The three different activities show different growth rates when this approach is used (Figure 11.8). Cement manufacture had a negative rate of about -1%, while lime manufacture and limestone and dolomite use had growth rates of about 2.3% and 1%, respectively. When the total emissions from this sector are considered, the growth rate was about 1%. This is not far from the estimated annual employment growth rate for Nevada's nonmetallic Mineral sector, which is expected to be 1.3% between 2010 and 2020[38]. Projections for the total emissions from this sector were also estimated using the employment growth rate, further assuming that it would hold constant for the period 2020-2030 as well. As Figure 11.8 shows, differences between the two approaches are minimal, if not negligible (0.07 $MMtCO_2eq$ in 2011, or about 4% of total IP GHG emissions projected for the same year), in particular at the end of the projection period.

[38] http://www.nevadaworkforce.com/cgi/dataanalysis/

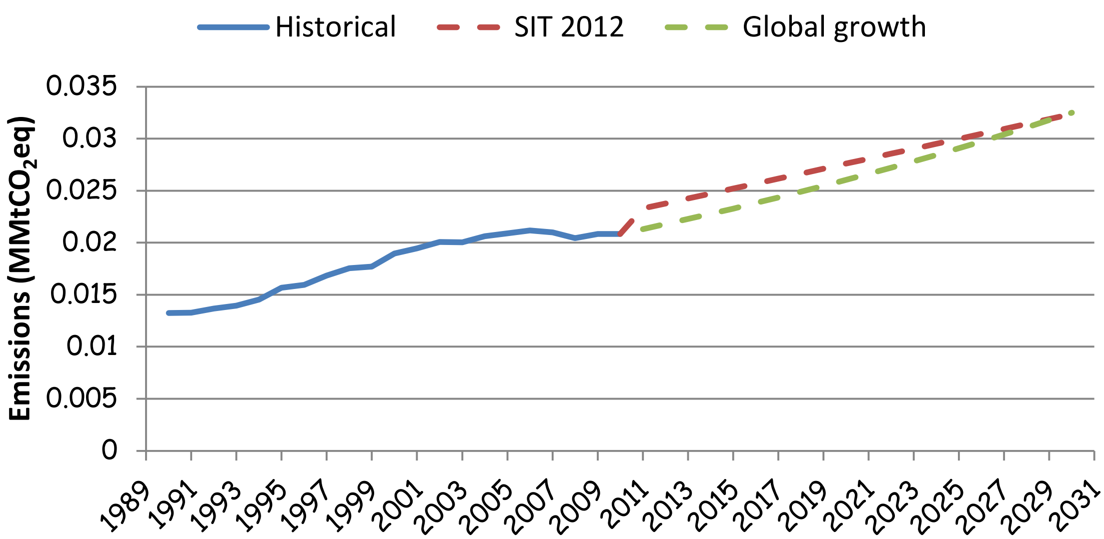
Figure 11.8: Historical (solid lines) and projected (dashed lines) emissions for cement manufacture, lime manufacture, limestone and dolomite use. The total emissions from these activities are represented with a solid black line. Projections for total emissions are shown as estimated using 1990-2010 trends (SIT 2012, black dashed line) and the sector employment growth rate expected for Nevada between 2010 and 2020[38], and assumed to be similar for 2020-2030 (dashed red line).



11.3.2.2 Soda ash consumption

The last economic downturn has affected soda-ash industries throughout 2009[36]. However, soda-ash production is expected to increase and world consumption is forecast to range from 2.0% to 2.5% per year for 2012 through 2014[36]. The analysis of the 1990-2010 trend led to an average annual growth rate of 1.7%. Differences in projected emissions using the two different growth rates are, however, minimal (Figure 11.9).

Figure 11.9: Historical (solid line) and projected (dashed lines) emissions for soda ash consumption. Results from two different approaches used to estimate 2011-2030 consumption are shown. In the first approach (SIT 2012, dashed red line) the 1990-2010 trend was used to project 2011-2030 emissions. In the second approach, a constant annual increase of 2.25% (global consumption growth for the period 2012-2014, USGS Minerals Yearbook 2010) was applied starting from 2011 (global growth, dashed green line).



11.3.2.3 Ozone Depleting Substance Substitutes (ODSS)

In its non-CO_2 GHG Emission report[39], EPA predicts an annual increase of the high GWP (HFCs, CFs, and SF_6) emissions of 4.3%, and 3.7% for the periods 2010-2015, and 2015-2020, respectively. These rates were revised and updated in the 2011 draft report[40], see also Table 11.3).

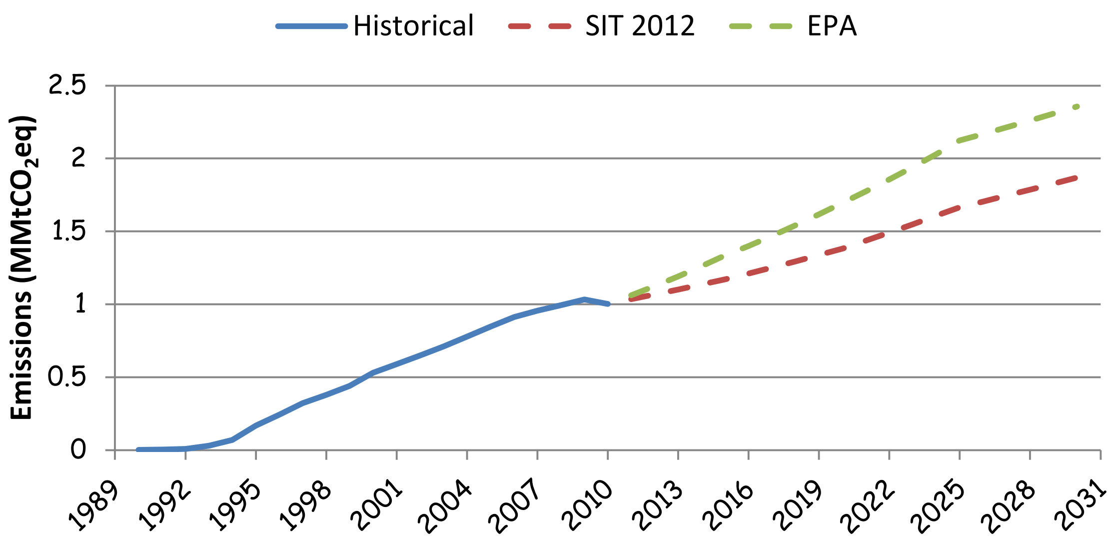
Table 11.3: Annual rates of high GWP emissions for U.S. IP sector accordingly to EPA non-CO2 GHG Emission report[40].

2010-2015	2016-2020	2021-2025	2026-2030	2031-2035
5.9%	4.9%	4.6%	2.1%	1.7%

These rates were used to project Nevada ODSS emissions and compare them with the emissions obtained by extrapolating the 1990-2010 trend. Figure 11.10 shows historical and projected ODSS emissions as calculated using both approaches. ODSS emissions increase less rapidly with the SIT 2012 approach, reaching only 1.9 MMtCO_2eq in 2030, compared with 2.35 MMtCO_2eq estimated using EPA projections. The difference between the two methods (0.5 MMtCO_2eq , or 24%) is remarkable, but still relatively negligible if compared to the total GHG emission projected for Nevada in 2030 (less than 1% of approximately 50 MMtCO_2eq) and if considering the overall uncertainty associated with these estimates.

[39] 2006, Global Anthropogenic Non-CO_2: Greenhouse Gas Emissions: 1990-2020, http://www.epa.gov/climatechange/EPAactivities/economics/nonco2projections.html
[40] (DRAFT: Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2030, http://www.epa.gov/climatechange/EPAactivities/economics/nonco2projections.html

Figure 11.10: Historical (solid line) and projected (dashed lines) emissions for ODSs. Estimates were calculated using EPA projections[40] (EPA, dashed green line) and by extrapolating the linear trend observed in the period 1990-2010 (SIT 2012, dashed red line).

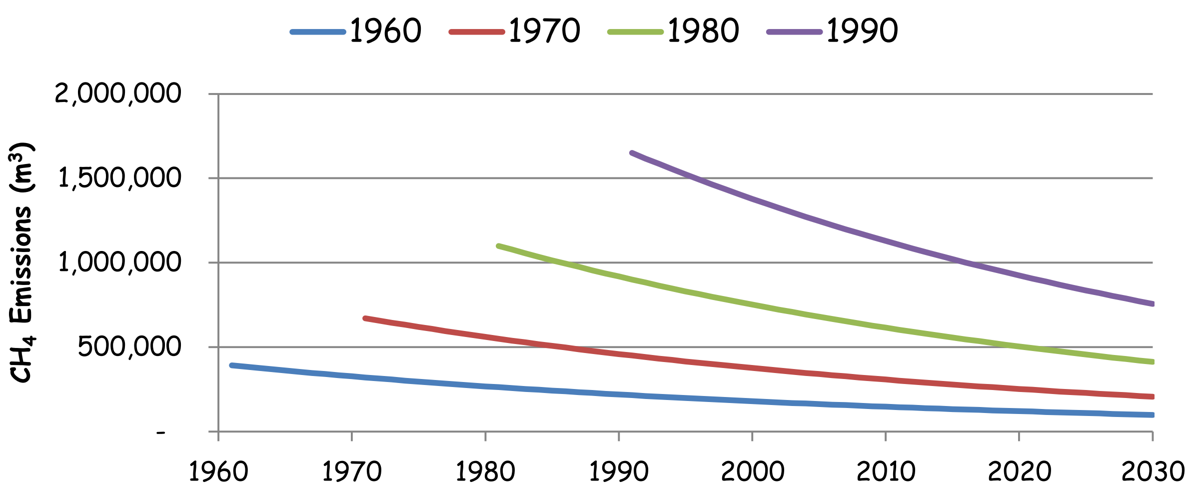


11.4 Emissions from solid waste management

11.4.1 Historical Emissions

In order to estimate emissions from landfills (mainly CH_4) the amount of waste emplaced is required through several decades of landfill activity. This is because landfill waste continues to emit CH_4 for several decades since its emplacement. Emission rates follow an exponential decay curve, quickly diminishing after a few years, but still being larger than zero for the next three to six decades (Figure 11.11), depending on the climate of the region (decay takes longer in arid climates).

Figure 11.11: Estimated CH_4 emissions from the Sunrise landfill. Each line represents the emissions from waste emplaced in different years, which slowly releases CH_4 following an exponential decay. Each line starts with different emissions because the waste emplaced each year is different (annual waste disposal increased consistently from the opening of the landfill, following the population growth in Nevada). In order to estimate the total emissions from a particular year, the contribution of each line needs to be considered. However, because only four years are shown for clarity, total annual emissions calculated using this chart would only represent a partial estimate (see Figure 11.15 for actual estimates). The model used in this report calculated annual total emissions by considering the waste emplaced in all years of activity. The Sunrise landfill opened in 1955 and closed in 1992.



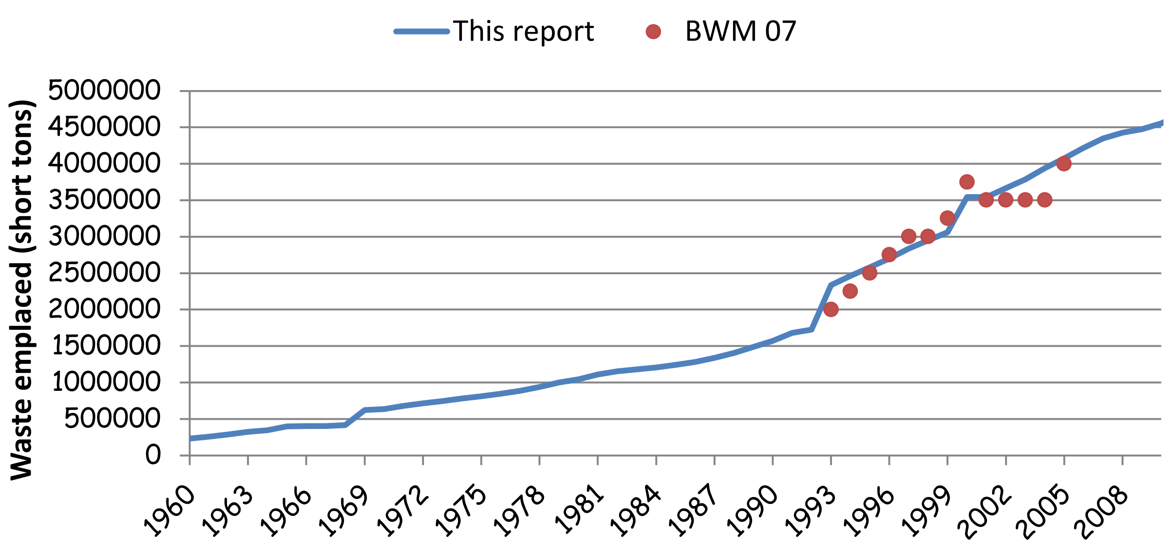
Data from the Nevada Statewide GHG Emission Inventory and Projections - 1990-2020 (2008), State of Nevada Solid Waste Management Plan (2007), and EPA Landfill Methane Outreach Program[29], were integrated to obtain the most up-to-date estimates of waste in place (WIP, i.e. the amount of waste emplaced since the beginning of landfill activity) in each of the main largest municipal waste landfills in Nevada (Table 11.4)

Table 11.4: Largest landfills in Nevada used to estimate statewide emissions from solid waste management (From LMOP 2012[29]). LFG and LFGTE refer to landfill gas collection, and landfill gas-to-energy, respectively.

Landfill Name	Landfill City	Waste In Place (tons)	Year Landfill Opened	Landfill Closure Year	Gas recovery system
Lockwood Regional LF	Sparks	25,139,396	1969	2035	LFGTE from 2012
Apex Regional LF	Apex	50,000,000	1993	2516	Flaring and LFG from 2000, LFGTE from 2012
Boulder City LF	Boulder City	2,319,518	1930	2017	
Elko City LF	Elko	962,000	1953	2081	
Ormsby SLF	Carson City	5,276,832	1965	2012	
Pahrump LF	Pahrump	25,980	1991	-	
Sunrise Landfill	Las Vegas	18,000,000	1955	1993	Flaring and LFG from 2002
Winnemucca LF	Winnemucca	174,642	1971	1992	

WIP for each landfill was redistributed across the activity years based on Nevada's population (Figure 11.12).

Figure 11.12: Total emplaced waste in the municipal solid waste landfills as modeled in this analysis. The estimates from the State of Nevada Solid Waste Management Plan (2007) are reported for comparison (BWM 07).



In order to account for the presence of gas recovery systems, the SIT 2012 model for solid waste management emissions was run independently for all the landfills with no gas recovery systems, the Apex, and Sunrise landfills assuming that 10% of produced CH_4 is oxidized and not released in the atmosphere (as from SIT 2012). CH_4 emissions from Apex and Sunrise were decreased starting from the years the gas recovery systems were put in place, assuming a recovery efficiency of 75% (as from the 2008 Nevada Statewide GHG Emission Inventory and Projections - 1990-2020).

Emissions from industrial waste management are assumed to be a fixed fraction of municipal soil waste. In the absence of local data, SIT 2012 recommends using the national ratio of 7%. However, as reported by 2008 Nevada Statewide GHG Emission Inventory and Projections[1], in Nevada there is a significant amount of industrial and special waste emplaced in the State's landfills, far exceeding the national average. For this reason, the emissions from industrial waste were assumed to be 50% of emissions from municipal waste[1].

11.4.2 Projected Emissions

Waste production and hence emplacement in landfills is dependent on population growth. Figure 11.13 shows the relationship between total waste emplacement data (estimated using the method described in Section 11.4.1) data and Nevada's population (from Nevada State Geographer) from 1960 to 2012. This relationship and the estimated population growth were used to project total waste emplacement in Nevada's landfills for the period 2010-2030. Two out of the three landfills that have gas control systems (Apex and Lockwood, see Table 11.4) are scheduled to close after 2030. For these landfills, waste emplacement for the period 2010-2030 was estimated by linearly extrapolating the respective historical trends (Figure 11.14). The Sunrise landfill was closed in 1993 but is still emitting CH_4 which is largely recovered by flaring and LFG technologies.

Figure 11.13: Relationship between total emplaced waste and Nevada's population

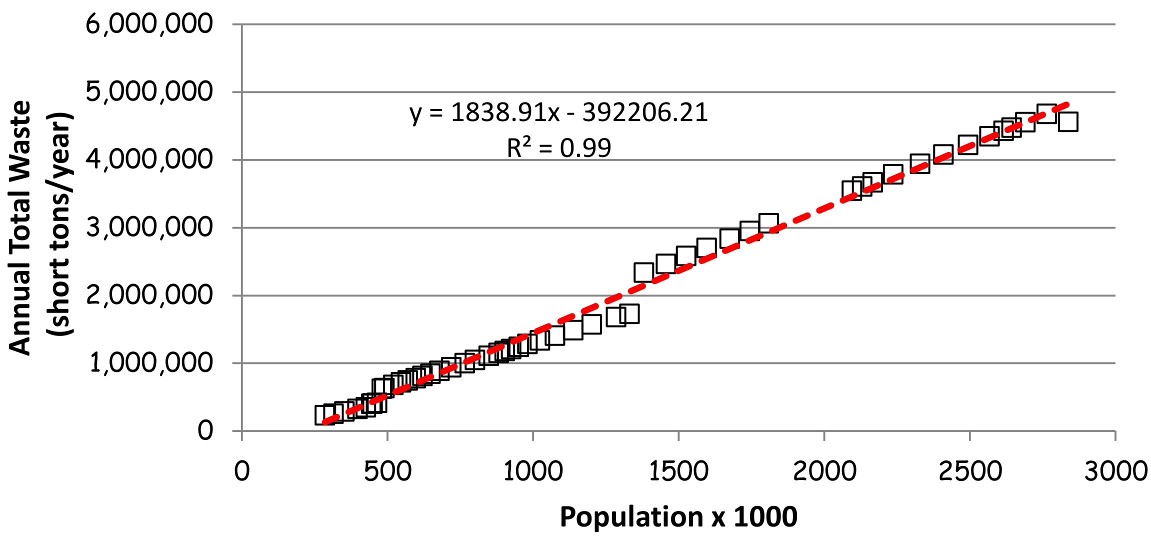
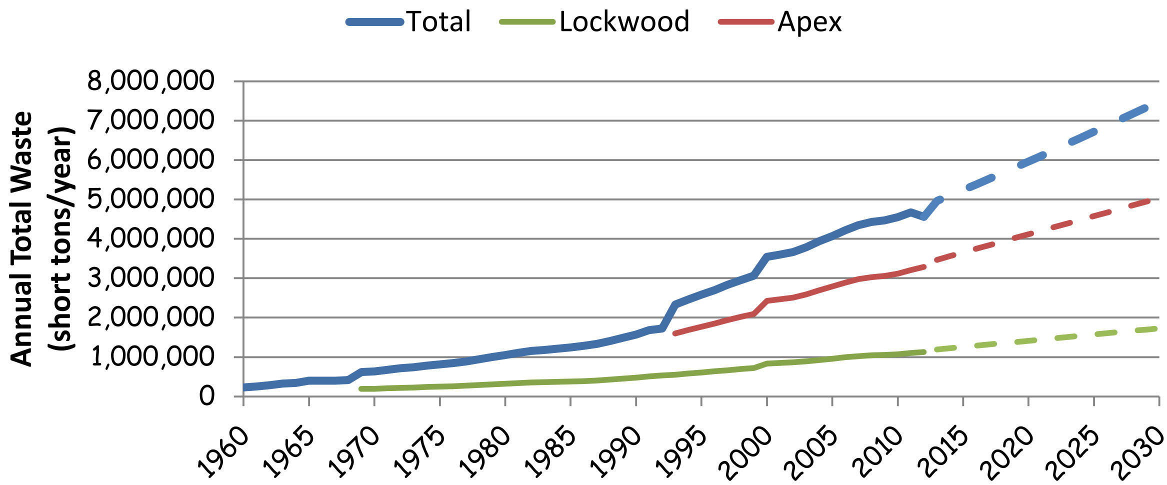
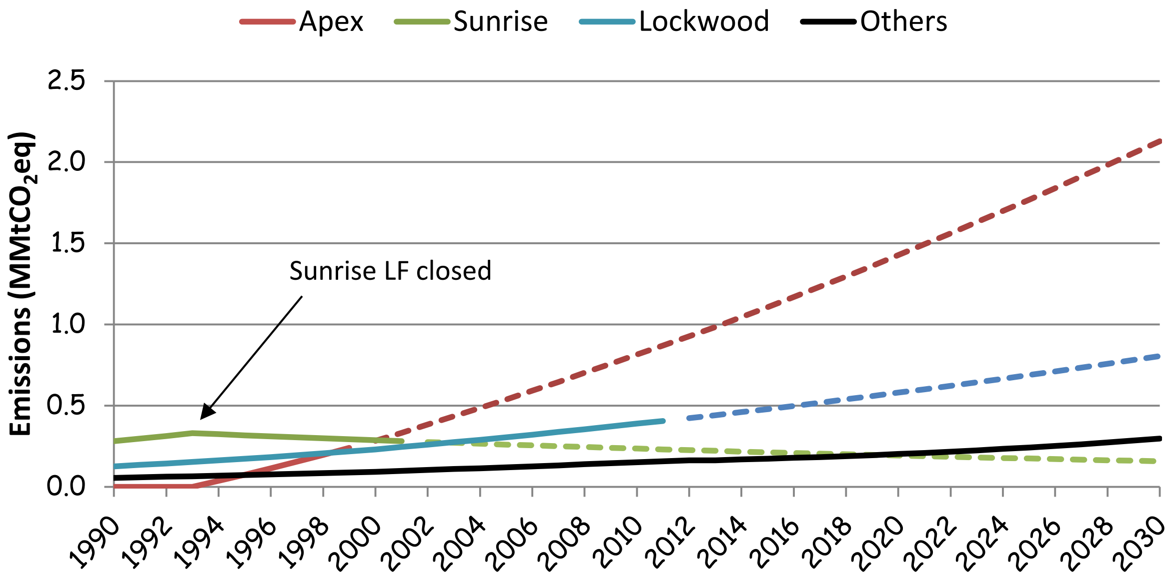


Figure 11.14: Historical (solid lines) and estimated (dashed lines) waste emplacement for Nevada, Lockwood and Apex landfills for the period 1960-2030. Total projections for Nevada were estimated using the relationship in Figure 11.13 and the projected population growth for the period 2010-2030. Projections for Lockwood and Apex were linearly extrapolated from their respective historical trends



Emissions were calculated using SIT 2012 for all the landfills without gas-recovery systems and for each one of the landfills with flaring, LFG, and/or LFGTE. Emissions factors and other assumptions were the same as those used for the calculation of historical emissions (see Section 11.4.1). No other landfills were projected to be equipped with gas-recovery systems during the period 2010-2030. This assumption could lead to overestimating the amount of GHG released by the waste management sector in the future, because it does not account for potential additional GHGs recovered and hence not released into the atmosphere. However, the three landfills currently equipped with gas-recovery systems account for the large majority (more than 90%[29]) of Nevada's waste in place (WIP). It is likely that any additional gas-recovery system in any of the remaining, or new, landfills will not substantially change the projected total emissions by this sector for the period 2010-2030. Figure 11.15 shows the historical and projected potential emissions for the Apex, Sunrise, and Lockwood landfills, individually, and total emissions from all the others landfills reported by LMOP (Table 11.4). Emissions from landfills are dependent on the total amount of WIP hence they are increasing in all the landfills, with the exception of the Sunrise LF, which was closed in 1993. However, the majority of these GHG potential emissions (CH_4) are not released into the atmosphere but recovered by systems such as flaring, LFG, and LFGTE (dashed lines in Figure 11.15).

Figure 11.15: Historical and projected emissions for the landfills (LF) individually considered in this report (Apex, Sunrise and Lockwood) and all the others LFs reported by LMOP (see Table 11.4). Solid lines identify the period when the LF did not have any gas recovery technology. Dashed lines identify the period when such technologies were present in the LF.

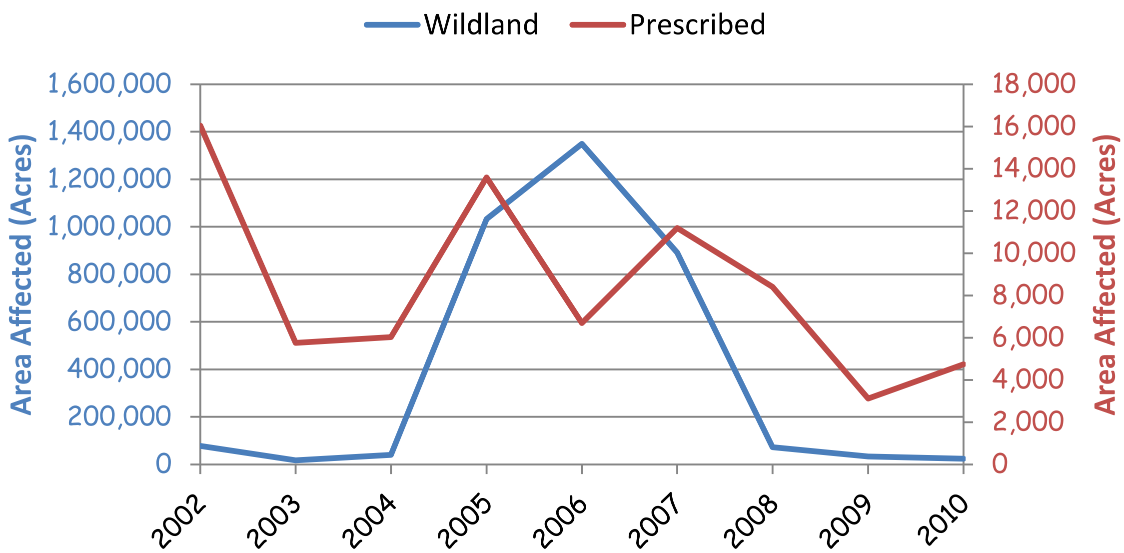


11.5 Land Use, Land Change, and Forestry Sector Emissions

11.5.1 Fire emissions

Emissions from either wild- or prescribed fires are estimated only for CH_4 and N_2O, as released CO_2 was previously absorbed from the atmosphere through photosynthesis. Historical data (period 2002-2010) on fires in Nevada was obtained from the National Interagency Fire Center (NIFC[41]).

Figure 11.16: Affected areas by wild and prescribed fires in Nevada (source: National Interagency Fire Center[41]). Two different ranges of scale are provided for wild- and prescribed fires.



Estimates for years from 1990 to 2001 were calculated by averaging data from 2002-2010 after removing the highest and the lowest values from the time-series. SIT 2012 requires providing the type of vegetation affected by the burning because different types of plants are characterized by different combustion efficiencies. As this information was not available, it was assumed that 90% of the land affected by wildfires was covered by shrub, and the remaining 10% by temperate forests. Similarly, 50% of the land affected by prescribed fires was covered by shrub and 50% by temperate forests. These assumptions were based on the following considerations: a) land covered by shrub-like vegetation is approximately 85% of the Nevada's land, versus only 11% of forest coverage (2006, Multi-Resolution Land Characteristics Consortium, MRLC, Figure 10.1), and b) dry, open, shrub-like vegetation may be a more likely fuel than temperate forests. In order to evaluate the potential effects of these assumptions, the emissions from fires were also calculated under two 'extreme' scenarios: all fires (both wildfires and prescribed) occurred on shrub-land (i.e., the largest possible amount of emissions, as shrub have higher combustion efficiency than forest vegetation); all fires occurred on forested land (i.e., the smallest possible amount of emissions). Results (Figure 11.17) show that there is a significant difference between the two scenarios considering the largest and smallest possible amount of emissions (about 3 $MMTCO_2eq$, or 40%). However, the 'all-forest' scenario, while useful to define the lowest limit for the

[41] http://www.nifc.gov/

range of potential emissions from fires, is extremely unlikely to have occurred (or to occur in the future). Therefore, the assumptions about distribution of fires adopted in this report should lead to estimates that are somewhat close to the actual emissions.

Figure 11.17: Total GHG emissions caused by fires under three different scenarios: 90% of wild- and 50% of prescribed fires were on shrub-land (This Report); all fires were on shrub-land (All Shrub); all fires were on forests (All Forest).